McGRAW-HILL
INDUSTRIAL ORGANIZATION AND MANAGEMENT SERIES
L. C. MORROW, *Consulting Editor*

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Fundamentals of Successful Manufacturing

McGRAW-HILL

INDUSTRIAL ORGANIZATION AND MANAGEMENT SERIES

L. C. Morrow, *Consulting Editor*

Editor, Factory Management and Maintenance

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This book is gratefully and affectionately dedicated to the manufacturers whose operations have supplied the various examples used.

PREFACE

Objectivity is one of the most useful qualities an executive can possess, but it is not always easy to achieve. The purpose of this book being to assist the reader in *thinking objectively,* it therefore seems fitting to start with a word or two about this important mental process. There are many ways of defining it, but the one I like best calls it "the grasping of and treating with *facts* as they *are* and not as we would like to have them or think they may be."

To succeed in thinking objectively we must cast off personal considerations, beware of traditions, suspiciously scrutinize prior arts, and, above all, avoid being led unwittingly down the beaten path or into a rut. Many years ago I was very much impressed with an allegory wherein the hero Jurgen rode on a centaur to a beautiful garden located between dawn and sunrise in "The Land of Things as They Are." The rest of the story was about how different he found everything in this interesting place from the everyday life to which he was accustomed. One might say that the centaur taught Jurgen how to think objectively and to substitute fact for fancy.

To think objectively about a very complicated subject, such as manufacturing with all its myriad details, it is helpful to try to arrange these details in logical order. When this has been done, they will form a pattern that we can recognize and comprehend as the whole, exploring its various aspects from without and gaining a certain familiarity with it. This would be impossible were we to become enmeshed in the morass of its minutiae, since our judgment could not fail to be biased by the gravitational fields of the surrounding details. It is always much easier to tell your wife that she already has several hats and does not need a new one than it is to resist the salesman who explains how smart you will look in the factory finger-blocked number that assures you of permanent glamour.

The following pages are the result of an attempt to arrange the various details of manufacturing in logical order for the purpose of clarifying my own thinking, and it is my earnest hope that they will perform similar service for the reader.

GEORGE G. HYDE.

DARIEN, CONN.,
August, 1946.

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CASE HISTORIES

In illustrating the material contained in this book, it has frequently been necessary to use examples of various kinds. Wherever these examples have been taken from real life, they are designated as *cases* and serially numbered. There are 37 in all, and they are listed and titled for identification in the following table. Their origin, in most cases, must remain anonymous for obvious reasons.

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Fundamentals of Successful Manufacturing

INTRODUCTION

AMERICAN industry is constantly faced with the gargantuan problem of keeping itself abreast of the times. This process of change or modernization is generally, or should be, a gradual evolution. For many it means making very small changes from time to time, but for others it may necessitate a clean sweep. There will also be a large number among us who, although they have never been manufacturers before, will want to be from now on. They will have acquired a taste for it through their work in, or contact with, industry, or they will have invented or acquired the rights to a new product and they will want to exploit it.

Some of the old heads will say, "Stay out! There are enough of us in it now," but they will not only be wrong, they will be ignored. Many of the older companies have missed the boat during the last few years, and they will go down under competition, leaving their places to be filled by new enterprises.

It is the aim of this book to help the new manufacturer get his enterprise going and also to assist the existing one to gird his loins for the future. The approach will be largely from the standpoint of helping in the establishment of a new enterprise, but those whose problem is one of modernization only can, I hope, get help with that part of their problem which needs changing. I recommend particularly to the existing manufacturer those portions dealing with organization, for it has been my experience that nearly all industry could do with a little brushing up on these matters.

When the enterprise consists of making something besides money, it is classed as manufacturing, and there are certain things that are common, in a greater or lesser degree, to all manufacturing. It is the purpose of this book to outline them briefly. It is not intended that it shall be a comprehensive treatise covering every phase of manufacturing but rather a sort of primer or résumé of fundamentals.

When I was a college freshman in 1915, I noticed that several of our textbooks in machine design were published in 1876. I went to the professor in high dudgeon demanding to know why, when we were paying for a modern technical education, we were using texts from the previous century, written by men who were dead long before any of the class was born. His explanation was something I have never forgotten and did me more good than any other one thing I learned in school. The substance of it was that, four years being much too short a time to teach a student all there was to know about engineering, they had decided to give us only the most important things, which were the fundamentals. "These," he said, "do not change with time, and when you are faced with a very complex problem, you will find that if you break it down into the fundamentals it will be very much easier to handle. It is much simpler to solve several easy problems than one hard one. Learn the fundamentals carefully and the complicated modern combinations will readily yield."

This process of taking a problem apart and analyzing each element separately is part of what we now call "objective thinking." It is the antidote for being in the position where you "can't see the forest for the trees."

CHAPTER I

DETERMINING THE POLICIES

Sound policy is the hallmark
of intelligent administration.

DETERMINING THE POLICIES

EVERY enterprise has to have some reason or excuse for existing. The French call this the *raison d'être.* There are nearly as many of these reasons as there are enterprises. Some are good, some are bad, and others are in between.

Usually someone or some group of people has something that everyone else doesn't have, and the enterprise results from an attempt to exploit it for the benefit of its owners. It may be a patent, a special skill, a source of raw material, access to a market, or just an idea.

Purpose

The primary purpose of any enterprise, unless it is charitable or educational, is to make a profit, foreign ideologies notwithstanding, and there are several ways of considering the purpose. One is to *make* the product for less than you have to sell it for, and another is to *sell* it for more than it costs to make. Both are true, but the former seems to me a little better way of looking at it. It implies an effort to make the product at low cost, whereas the second proposition implies an effort to sell it for a high price.

Costs

There are manufacturers whose policies are based on the first concept and there are those who go by the second. In the past both have been successful with, I should say, a slight edge in favor of the cost conscious. The trend of modern times, however, is away from the idea of getting all the traffic will bear and toward the idea of manufacturing at the least possible cost.

The reason for this trend is not any high-mindedness on the part of the manufacturers, but simply the fact that they have found that it pays in the long run. Let us then establish as the first policy of our new enterprise that we shall endeavor to make our product at the least possible cost and that we shall continue to make every effort to reduce costs as time goes on.

Price

The second consideration should be whether we shall continue to sell at the same price, regardless of how much we have reduced our costs, as long as we can get it. There are many executives who would immediately answer this question by saying, "Why not?" The answer is that to do so would be unfair to part of our enterprise. Every enterprise is composed of three fundamental units of interest, and all three must be treated fairly if the enterprise is to be successful in the long run. These three units are:

1. The stockholders or owners of the enterprise
2. The personnel or those who carry on the business, including management and labor
3. The customers who make possible the continuance of the enterprise

If we are unfair to any of these three, it will react against us in the long run. If the stockholders receive no return on their capital, they can liquidate the enterprise and, make no mistake about it, they surely will. If the personnel receive no return for their efforts, they will quit as soon as an opportunity of working for someone else presents itself. If the customers get no advantage from their patronage, they will soon find other sources. They can always do this, too, no matter how well intrenched the manufacturer thinks he is. I have seen many a customer set up another enterprise in business to break up what he referred to as a "vicious monopoly."

Speculation

There is also the matter of whether or not the enterprise will engage in speculation in raw materials. Some companies, using large amounts of raw materials, try to buy large quantities when the market is down and stay out when the market is up. Undoubtedly there is money to be made in this practice, but wherever there is money to be made, there is also money to be lost. It is probably smarter to say, "Are we speculators or are we manufacturers?" Engaging in material speculation not only necessitates the carrying of large inventories but requires an undue amount of executive time that could probably be more profitably used in the conduct of the business. Some executives find it great fun but then playing roulette, the horses, or the stock market is great fun too; and the question should be asked whether or not the stockholders would approve of the use of the company's funds for any of these activities. The answer is, of course, obvious, and the difference between gambling in materials and in the other forms mentioned might be difficult to define.

Sales

The policies of the enterprise with regard to sales should be given early consideration. Will the company sell direct to the consumer through company-owned retail outlets or branches or will it use mail-order techniques? If the company does not sell direct, will it sell through wholesalers or jobbers?

There are too many different ways of marketing to go into all of them in a book of this kind so suffice it to say that the method of marketing should be determined as one of the general policies of the company.

Others

The general policies with respect to personnel and accounting procedures as well as the engineering policies should be determined as soon as possible. For instance, how much will we spend each year on research and development or what type of incentive pay plan will we use?

Details

Next there are the more immediate policies to consider. It is assumed that we knew what we were going to make from the beginning so let us determine how many per year. The different sizes or models of each product and the quantities of each should be decided. A market analysis is of great help in determining these factors. Are we going to start with full operation or partial operation? Let us plan our facilities for full operation, and establish stages so that we do not block ourselves during expansion and necessitate expensive changes in layout and machinery.

Record

Above all, as we determine our policies, let us write them down together with the reasons therefor so that there will be no misunderstandings among us, and we will not forget where we are going. The fact that we write them down does not make them less subject to beneficial change. It is always possible and advisable to change a policy if it is found wanting for any reason at all.

IN DETERMINING YOUR POLICIES

DO	DON'T
1. Think objectively	1. *Don't* think emotionally
2. Determine broad policy first	2. *Don't* be vague
3. Then work out the details	3. *Don't* keep the policies a secret
4. WRITE THEM DOWN	4. *Don't* hesitate to change

CHAPTER II

DESIGNING THE PRODUCT

One trial is worth a thousand expert opinions.

DESIGNING THE PRODUCT

THE most important thing about designing the product is that it should be done by competent and experienced engineers who are possessed of a considerable amount of forethought—the more the better. I am assuming that it is a new product and that it has not, as yet, been on the market and had the acid test of actual use. Therefore, everything possible should be done to try to forecast not only its possible uses but the probable abuses that it will have to withstand.

Abuse

Be sure that it will be abused by experts, and when it fails, that they will try to hold you responsible no matter how they have mistreated it. Usually they lie about what they did to it, and they will often show you a broken shaft, point to the break, and say, "You see, it's crystallized." If you try to explain that all metals are crystalline in structure, and if they were not they would probably have no rigidity of form whatever, and that there must be some other explanation for the break, they will become angry, vilify you, and assert to all and sundry that you acquire your materials at the city dump. If you don't believe this, ask any "customer complaint man."

Of course, there is a limit as to how far you can go in designing a product to stand up under abuse, but go as far as you can.

Case I—The Case of the Versatile Ash Tray

Only last week I dropped into a friend's office to pick him up for lunch and found him trying to drive a nail in the wall with a glass ash tray in order to hang up a picture. It so happened that he didn't break the ash tray, but if he had, it is 10 to 1 he would have left it on the reception room table with the chip out of it to advertise to all the fragile quality of the manufacturer's merchandise. I am sure he would not have put a sign on it saying, "I broke this ash tray trying to drive a nail with it." He couldn't live that down himself.

Designing vs. Inventing

There is quite a difference in designing a product and inventing it. People often get these two mixed up. The inventor conceives it and, as a rule, there he stops. He should stop there, at any rate. The peculiar qualities of mind that enable a man to invent things are not the ones that would enable him to develop and exploit his inventions. Now some men have both qualities, and they are, of course, rarer than those with either one; but I have noticed, through many years of close association with men of this type, that they never exhibit both qualities simultaneously. The transition from the state where the inventive quality is dominant to the state where their more practical abilities dominate usually takes anywhere from 2 to 30 days or longer, and they rarely are capable of designing or developing their own inventions. Inventors and designers should work in teams as, indeed, many of the more successful ones do.

Break It Down

The more complicated the product is the more involved and intricate the design becomes and the harder it is to look into the future. Therefore, I recommend that during the designing of any product, of even moderate complexity, experimental work be carried out separately on each element.

Case II—*The Case of the Smoking Stacks*

A short time ago I worked on the development of a very large and complicated device for a large utility company. It was intended to measure the amount of solid matter in the stack gases. The stacks were very large, about 25 ft. in diameter, and to experiment directly on the stack itself would have caused very costly shutdowns. The procedure used was to break the device down into its various elements, to develop each one separately, using surrogates for the other elements during the tests, and, when all the elements had been separately proven, and then only, make the application to the stack itself. By working this way over 90 per cent of the work could be, and was, done in the laboratory.

Test Samples

Many companies make several handmade samples and put these out in actual service to determine customer acceptance and the location of the weaknesses.

Case III—*The Case of the Lucky Wife*

I developed a small product back in the early days of the depression, and everyone to whom I showed it said that it was too expensive. I did not believe it, however, and had an idea that once they used it they would not want to be without it. I made 12 samples and gave them to the very people who had gagged on the price of $7.50. Three months later I went around to each of them and said that there were no more available, nor would there be, but that I had run into someone who wanted one and thought perhaps they would want to sell theirs to him. They all asked if he were some friend of mine that I wanted to get one for and I told them, "No, I have never even seen the man," which was only

> too true. Not 1 of the 12 would sell their "widgit" even when I told them I was authorized to pay them up to $50 for it. A recent checkup shows that 11 of the widgits are still in service. The remaining one was broken when its owner threw it at his wife and missed. It hit against a stone chimney and cracked the main casting. This is an example of the abuse to which products are often put.

It has been previously said that this book is not intended to be a comprehensive work covering the entire subject of manufacturing but simply a sort of outline of the subject, hitting the high spots or such of them as I don't forget. I want to reemphasize this and to say further that I have no intention of trying to tell you how to do everything, or anything for that matter. I simply want to point out some of the things that should be or should have been done in the establishment of a manufacturing enterprise and to call attention to some of the pitfalls that are yawning to catch the unwary.

Myths

In product design one of the chief things to watch out for are the "old wives' tales." These myths beset the engineer on every hand, and they are usually wound up in a ball of tradition and wrapped in a thin coat of experience. It has been a hobby of mine for some years to find them out and expose them. Although it has nothing to do with product design, I should like to tell you of one of them that has vitally affected one of our great amusement industries:

Case IV—*The Case of the Misplaced Clubhouse*

> Back in 1925 my father and I visited the Havana Jockey Club in Marianao, Cuba. On the first day we were there, we sat on the clubhouse porch and watched the races. I was immensely impressed by the fact that

the races were more interesting from this porch than from any of our American track clubhouses. The reason was simple. The clubhouse was located to the left of the grandstand and commanded a magnificent view of the stretch run. This is the part of the race where the final effort is exerted before the finish that takes place in front of the grandstand. In all our American tracks the clubhouse, where the most expensive seats are located, is invariably to the right of the grandstand, and the only view you can have from there is that of the horses pulling up after the race is over. If you take your field glasses and look down the track toward the finish line, you see the horses coming toward you and there is no way you can tell which is ahead if they are within four or five lengths of one another. I decided to find out why we Americans had so completely missed out on that important thing. I made many inquiries from everyone I could contact in the racing world, and, since my father had been for years attorney for the New York Racing Association, these were many. The universal answer was because they do it that way in England and racing came to America from there. It smacked of an old wives' tale but, I thought, the English ought to know. I pondered the question for a long time and finally the answer dawned on me. I could scarcely believe it so I called up my father and said, "Pop, do you remember when we were at the races in England in 1910?" He said he did, and then I asked, "Am I crazy or do I remember that the horses ran the other way around the track over there?" "Of course they do," he replied, "and they also drive on the left side of the street." There was the answer in a nutshell. The Americans brought the entire race track layout here from England; they reversed the direction of the horses, but made no compensating changes in the arrangement of the track. At Havana the horses run the same way as ours, but somebody had sense enough to transpose the clubhouse.

Another instance of old wives' tales interfering with modern practice occurred in the plant of a former client of mine:

Case V—The Case of the Grainy Steel

> They were cutting shapes out of steel plates and were wasting a lot of material because everyone thought there was a great difference in the strength of the material depending on the way the axis of bending lay with respect to the direction of rolling. The people in the plant were not entirely to blame for this misconception because nearly all the customers insisted that their material be cut in a certain direction with respect to the long axis of the rolled plate. I asked if any scientific determination had ever been made, and they laughed at me. They said that everyone knew that rolled plate had a grain similar to the grain in wood and that it was only reasonable that this would have some effect but no one could say how much. I talked it over with the plant metallurgist, and he agreed to make some rather exhaustive tests both metallurgical and physical on large samples. When the tests were complete he told me, "I feel sure there is a difference, but it is so small from 'longways' to 'crossways' that we have no instruments capable of measuring just how much the difference is." From then on we saved a lot of material, and to my knowledge there have never been any complaints.

The moral of these stories is never to accept any traditional ideas about whether a thing will do this or won't do that until you have made a thorough checkup. You would be surprised how much money you can save by spending a few dollars to get the facts.

Cooperation

Another very important factor in product design is cooperation between the Product Engineer and the Process

Engineer. I think it is safe to say that these two, working together, can save more money than any other combination in modern manufacturing. The thing to do is to try and fit the product to the process and vice versa before either one is frozen.

Improvement

The very minute the product is designed the Product Engineer should start trying to improve it. This should be a never-ending process, and his efforts in this direction should be augmented by as much research and as good development laboratory facilities as you can afford. It is only through constant pressure on improvement that a manufacturer can keep up with the parade in this day and age. Nor is it enough to keep up, you must be out in front if you really want to be successful. It is not always necessary to stop all production the minute you have found a way of improvement unless it is basic and far reaching. Many manufacturers make periodic model changes at which time they put into effect all the improvements they have discovered since the last change. The automobile is the outstanding example of the periodic model change although, I think, to bring out a new model yearly is a bit often for a product of such complexity. There is not enough difference in the yearly models of automobiles to warrant the necessary expense in tooling; but the manufacturers have been caught in the web of consumer demand, and if they don't bring out a new model yearly, the customer thinks he is not getting his money's worth. In point of fact, the customer is really the loser, for had he the patience to wait two or three years for a new model he would really have something worth while; and I think the automobile would advance quicker if research and development could be aimed at the more basic changes rather than at something quick and spectacular to boost sales. All the tricky chromium trim that came out in the last couple of years before the war did very little to improve the science of automotive transportation.

New Products

Improving the product should not be the only activity of the Product Engineer. He should direct his research and development activities toward the evolution of new products that can be added to or substituted for the existing ones should the public commence to tire of the old ones or, perhaps, to compensate for seasonal fluctuations. The public has a way of being capriciously fickle about such things too. I have seen the demand for a well-established product practically vanish overnight. There is usually some reason for this, but you never can tell what it is going to be until it is almost too late. Then if you are not ready with a new product, you are going to lose some money until you are. You never know when someone will come out with a new product that may render yours obsolete. This happens regularly in the machine tool industry, but fortunately for the industry a new tool is usually quite expensive in the beginning and it gives the established ones a chance to get their "faces lifted" and get squared off before they become completely obsolete.

Appearance

The last item I'm going to bother you with in regard to product design, although by no means the least important, is that of appearance. It is very difficult to overestimate the importance of product appearance, since it is the foundation of sales appeal. There are many manufacturers, particularly in the nonconsumer goods field, who scout any attention to appearance as foppishness. The man who uses tools, for instance, is said by those scoffers not to care what the tool looks like as long as it can do the job it is intended for. Nothing could be farther from the truth. I cannot tell you how many arguments I've heard among some of the best tool men in the country as to which tool looks the best. It may sound silly and all that, but the fact is it is true and, after all, why shouldn't it be? These men, when furnishing their homes, don't buy the first chair the salesman shows them because they can sit down on it, nor do they feel the muscles and examine the heart and lungs of a girl whom they feel is a likely candidate for a wife. Why, then, should they be oblivious to the appearance of an article of furnishing to go into the shop where they will spend as much time as they do in their homes.

There is a kind of "beauty" about a machine that is different from the usually accepted ideas on this subject. The appearance of a house, of a piece of furniture, or even of a tombstone may be enhanced by refined and tasteful ornament. Ornament has no place on a machine and will not enhance its appearance. This is a fact that has been only recently discovered. In the early days it was thought that a machine should have all sorts of gewgaws plastered all over it and that compression members should, if possible, be in the form of architectural columns. Tension members were often carved to resemble rope. Leonardo da Vinci, in a letter soliciting business, boasted that he could not only make the most efficient cannon in Rome but also the most beautiful. That was the style in those days, but it isn't any more. In designing a machine every effort should be made to have the appearance of the machine express the functional purpose for which it is intended and do so with the least possible effort. There is no sense in streamlining an object that will never have to pass rapidly through a fluid, but there is logic in having its exterior surface smooth, full, and free from reentrant angles to catch dirt or sharp projections to snag the clothing and scratch the skin.

The above remarks about design really apply to all forms of design and not only to machines. All the greatest designs that man has made in his entire history have been inspired by a desire to express frankly the purpose of the object. All attempts to achieve beauty of design through applied ornament alone have been dismal failures. To my mind one of the greatest works of man was the development of Gothic architecture, and the one characteristic that makes it great is that it is a completely pure expression of the structure. Of all the impressive details of Gothic, the most spectacular is the flying buttress that is so necessary structurally that without it the roof of Nôtre Dame would have been on the floor of the nave centuries ago.

Architects

I would like to offer a suggestion to product engineers that they may find very helpful. I have always found it a great help. Keep a good architect on your staff. This may seem a little odd to you if you are not familiar with the training and the work of an architect. Do not get one who has spent all his time at, and is only interested in, the designing of commercial or industrial buildings. Rather get a young man who has a good academic background and has been trained in *design*. He should be a good draftsman and have the ability to make a good rendering. He will be invaluable to you as you learn to appreciate the worth of his seemingly impractical training in design. Remember that design has been the same throughout the world and down through the ages, and our modern industrial work is just a small branch of one of the largest fields that mankind has ever entered. I recommend an architect rather than an artist for the training of the artist does not lay so much stress upon the expression of a purpose as does that of the architect. From the first day he spends in architectural school until he graduates he is learning to express the purpose of buildings in brick, stone, and steel, and it is not a Herculean task for him to adopt a slightly different medium and express the purpose of your product in the materials of which it is made. If you want to get a good idea of how it will look before you actually make it, he can give it to you through the medium of a rendering in pencil, water color, or pen and ink. Many architects have contributed a great deal to the war effort through their ability to make perspective and "explosion" drawings.

IN DESIGNING YOUR PRODUCT

DO	DON'T
1. Use competent designers	1. *Don't* take things for granted
2. Make test samples	2. *Don't* get caught napping
3. Get the facts	3. *Don't* jazz up the design
4. Coordinate product and process design	4. *Don't* underpay your brains

CHAPTER III

PROCESSING THE PRODUCT

In skillful processing lies
the secret of low costs.

PROCESSING THE PRODUCT

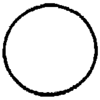
BY *PROCESSING* is meant the complete determination of how the product shall be made. This involves determining what operations are necessary, their description, their order of occurrence, and all other data necessary to their satisfactory performance. When applied to an operating plant, *processing* is usually referred to as *process analysis.*

Charts

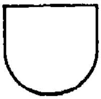
It is, perhaps, easiest to start with the preparation of a *process chart* that graphically represents the flow of all materials entering into the product and its passage through each operation to completion. It should also show the passage of the materials and the partly finished parts through storages, inspections, and delays as well as the various forms of transportation employed. In commencing to prepare such a chart, it is well not to go into too great detail at first. Start with a breakdown into the major operations, then add the minor ones, and finally add the details. Number each operation.

Symbols

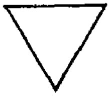
In preparing the chart the use of symbols will be found convenient, and there are certain ones that are generally used. The following are convenient:



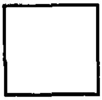
The circle represents an *operation,* which generally means the doing of any work on an object except transporting or inspecting it. Operation numbers or letters to denote the kind of operation may be placed inside the circle, for example, an *M* might indicate a machine operation and an *H* might indicate a hand operation.



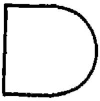
The inverted *D* represents a *transportation* that occurs when an object is moved from one place to another and when the movement is not caused by an operation or by the operator or by an inspector in handling an object. Inserted letters can indicate the kind of transportation such as conveyor, elevator, truck, hand, etc.



The triangle with the point down represents a *storage* where an object is protected against unauthorized removal. Inserted letters can indicate the kind or place of storage, or other important data.



The square indicates an *inspection* that occurs when an object is examined for identification, quality, or quantity or when any analysis or measurement, other than during an operation, takes place. Inserted letters can indicate the kind of inspection.



The *D* symbol indicates a delay of any kind other than a storage as when objects are piled to await an operation or removal. Inserted letters can indicate where the delay takes place, as in a tote box, on the floor, in a rack, etc.

Other symbols may be used to indicate special events as the particular case may require.

New Products

When processing a new product, I would suggest first making a chart showing only the main operations and storage points, as shown in Fig. 1:

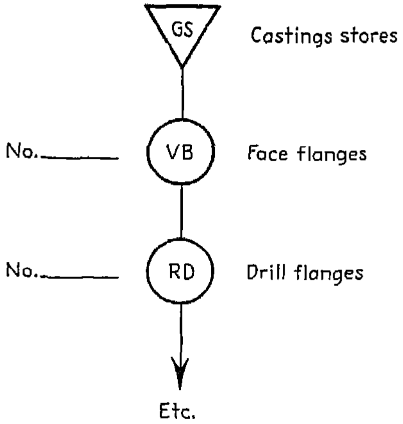


FIG. 1.—*GS*, general stores; *VB*, vertical boring mill; *RD*, radial drill.

A separate line should be prepared for each part or element of the product, and these lines should come together at points or operations of assembly or subassembly as shown in Fig. 2.

When this has been done, it can be expanded to show the principal movements and any unavoidable delays. Delays should, of course, be avoided except where production is done in batches when parts will necessarily have to be supplied to and removed from machines in quantities.

Analyses

However, if you are making an analysis of an existing process, the technique is entirely different. Show everything on the process chart, and then check it carefully in the shop to be sure you have missed nothing. Only then can you intelligently analyze it.

In original processing, when you have completed the process chart as far as you can and have written reasonably complete descriptions of the various events including batch sizes and quantities per unit time at each of them, do not under any circumstances consider the chart inflexible. Rather think that you have only made it to change, and if the subsequent steps do not indicate any changes there are only two possible reasons. The first is that these subsequent steps have been incompletely taken, and the second is that you are a great genius. A third reason is possible, but of such infinitesimal probability that it is scarcely worth mentioning. That is, that you have had good luck.

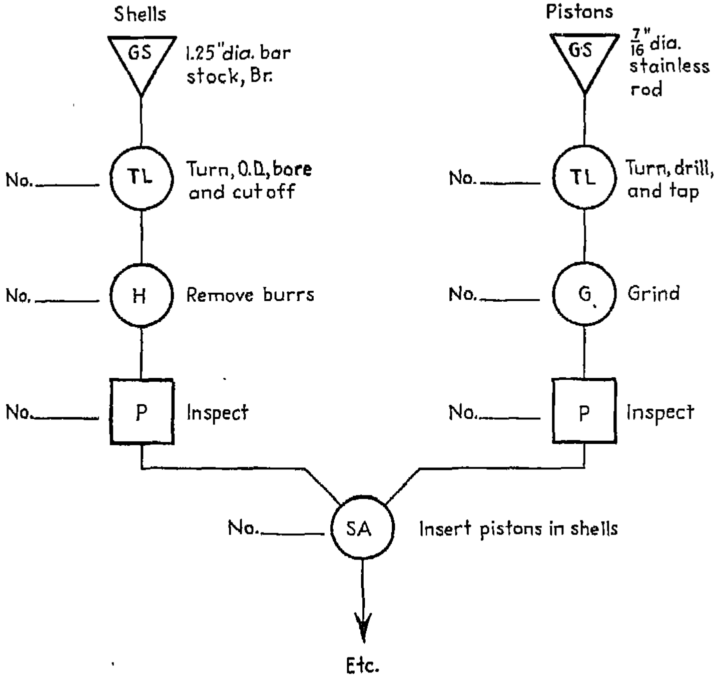


Fig. 2.—*GS,* general stores; *TL,* turret lathe; *H,* hand operation; *G,* grinder; *P,* process inspection; *SA,* subassembly.

Flexibility

This is probably as good a place as any for a word of caution that should apply to the entire enterprise but particularly to processing. *Never,* and I don't mean sometimes either, establish anything with the idea that it is permanent. No matter how good a job you have done it can always be improved and not necessarily by someone else. If you do the same job over ten times, each time it will be better than the previous one, and there is no limit to how far you can go. I do not recommend the slighting of a job with the idea that you will fix it up the next time you pass that way, but never get behind the eight ball so that if you see something needs improving you can't do it without causing a major upheaval.

Case VI—*The Case of the Floating Machines*

> I know one manufacturer who won't bolt down a machine, unless he has to, because next week he may get an idea that will improve his layout, and he doesn't want to cramp his style. All his electrical connections are made through plugs so he can pick up a 36 in. lathe and move it across the shop as you would a fan or an electric toaster.

There is a lot to be said for his philosophy although, like most things, it is not good to carry it to extremes. Flexibility is, undoubtedly, a great aid to progress, but rubber columns in the building would obviously have their drawbacks.

Operation Sheets

The next step in processing is to prepare operation sheets. These are usually 8½- by 11-in. sheets which describe, in the greatest detail possible, each operation and the instruments with which it is performed. It would be very difficult to exaggerate the importance of operation sheets. We have heard a lot of loose talk in recent years about "know-how." The making of an operation sheet is putting the know-how down on paper so that if the man that has it is suddenly removed from among us we don't have to shut down the plant. Operation sheets should have a lot of information on them, all that is known, but it is surprising how rarely they do. Many plants don't have any at all.

Case VII—*The Case of the Ancient Know-how*

> There is at least one manufacturer in the country who boasts wildly of his know-how and how it has been gradually accumulated over a period of more than 100 years. They have been making the same product since shortly after the Civil War. It involves the cutting of certain shapes from sheet material and up to last year they never had an operation sheet in the plant. The result was that no one knew what widths or lengths of sheet to order from the delivery schedules, and the nesting was never done twice the same. If, by luck, they got a good yield out of one order, it was a 10 to 1 shot that they would get a bad one on the next, and the general average was always bad. The Plant Manager refused to admit that operation sheets would do any good and said they always wrote the order data on the templates and that was enough. There were several thousand unfiled paper templates in a closet in the Superintendent's office and, true enough, the figures were still legible on a few where greasy fingers had happily failed to obliterate them. (These were the ones that were seldom used.) The rest of the data was obtained from the shear foreman. I had operation sheets carefully prepared for about two thousand of the most popular shapes, and the result was the saving of from 17 per cent to 42 per cent of the material depending on the particular shape.

In general, the information that should appear on the process sheet is as follows:

1. A description of the operation
2. The facility with which it is to be performed
3. Alternate facilities, if any
4. The part number
5. The part name
6. The customer if it is a special item
7. The economical lot size
8. The jigs and fixtures to be used
9. The tools and templates needed
10. Material specifications and ordering data
11. The speeds and feeds for machines
12. A drawing of the operation
13. The standard performance time †
14. General instructions
15. Special instructions
16. Yield in the case of cutout materials
17. Weight per piece
18. Revision record
19. Sheet number
20. Number of sheets to operation

I do not claim that all the above information should be on every operation sheet or that there are not other essential items for some operations that are not included here, but it should serve as a guide to their preparation. Every process has its own peculiarities, and operation sheets should be tailored to fit. Remember, it is better to have too much information on them than too little. It is especially important to have a drawing on the sheet even if it be most rudimentary. Remember what the Chinaman said about pictures:

> "One picture is worth a thousand words."

When first preparing the operation sheet, it will be impossible to get all the necessary data on it. Some will have to come later as a result of practical tests or experience. I have never been able to set *economical* speeds and feeds in advance.

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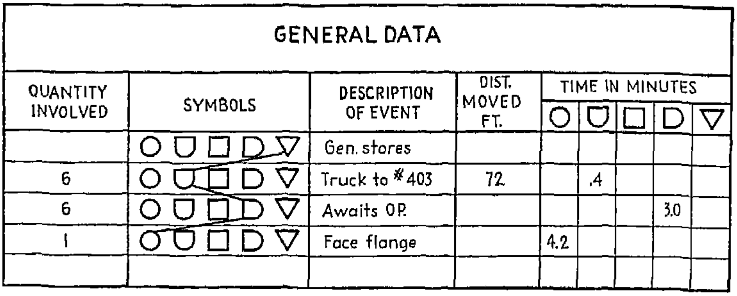
† Standard times are usually shown on the office copies only.

Another form for the process chart is shown in Fig. 3. This chart is more useful in making a process analysis than in the development of a process.



GENERAL DATA								
QUANTITY INVOLVED	SYMBOLS	DESCRIPTION OF EVENT	DIST. MOVED FT.	TIME IN MINUTES				
				○	U	□	D	▽
	○ U □ D ▽	Gen. stores						
6	○ U □ D ▽	Truck to #403	72		.4			
6	○ U □ D ▽	Awaits OP.					3.0	
1	○ U □ D ▽	Face flange		4.2				

FIG. 3.

Figure 4 shows still another type of flow chart. I prefer this for many purposes, particularly in developing a new production line. It doesn't carry as much data as the others, but it has a great pictorial value and one of the most important things in development is to keep the general or over-all picture always in mind. Some architectural designers have a very good technique for this. They start the design on rough paper with a 6B pencil. This physically prevents drawing in any detail until the general arrangement or *parti* has been completed. Then they change to about a 2B and gradually work up to about a 2H. Our eagerness to get on with the job is the principal factor that militates against us and it is, I suppose, only natural to want to get the detail nailed down before we complete the over-all conception. Between you and me, I am having the same sort of trouble in trying to write this book.

Now where were we? Oh, yes, we have taken a look

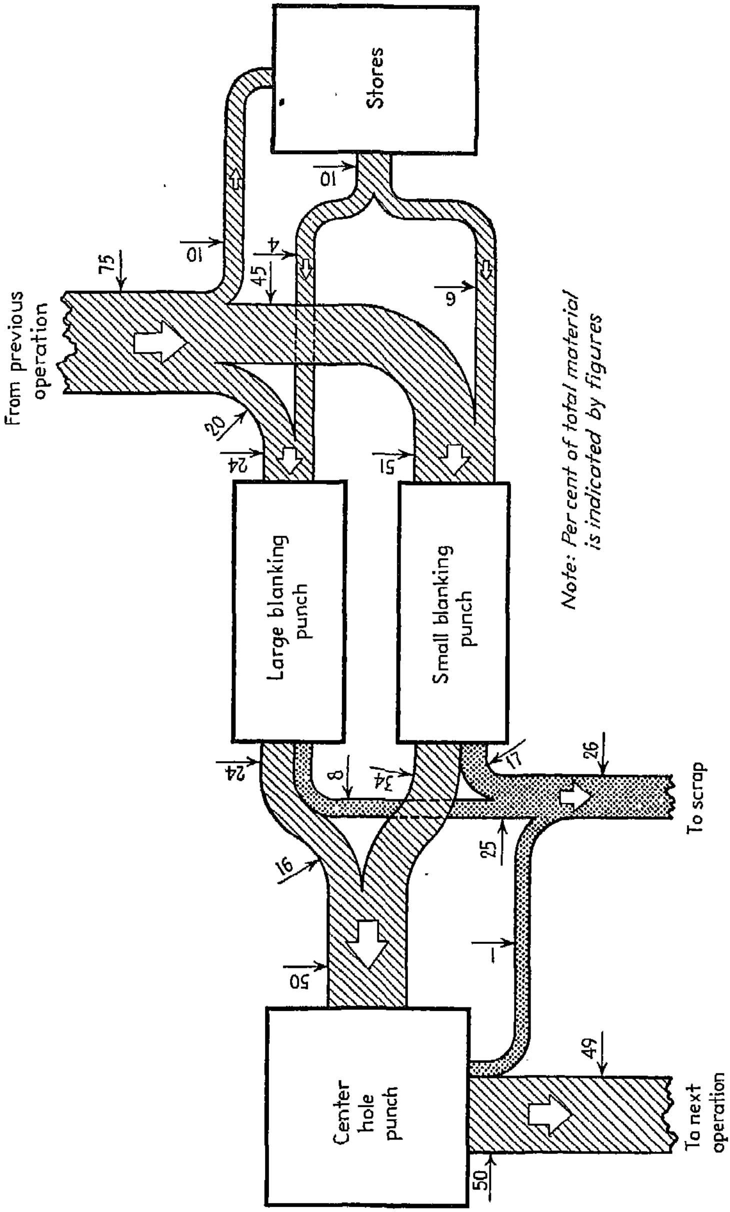

From previous operation
Stores
Large blanking punch
Small blanking punch
To scrap
Center hole punch
To next operation
Note: Per cent of total material is indicated by figures

FIG. 4.

at operation charts and touched lightly on operation sheets. While so doing, we have incidentally determined the operation sequence or routing. The next thing to consider is balancing or timing the "line."

Timing

As with the making of process charts, the techniques for establishing a new process differ from those which should be used in improving an existing one. In the latter case you have something to start with and to measure, but in the former you have to do a little guessing or, if you prefer, estimating. There isn't much difference between guessing and estimating except that estimating is supposed to be based on some prior knowledge. It is like two men at the race track—one assiduously studies the "dope sheets" before he bets and the other sticks a pin through the program. The first estimates; the second guesses. Which makes the most money? You tell me!

Rates and Units

Of course, a great deal of reliable data can be obtained as to the time rates on operations. For instance, if you have presses in the line, the manufacturers of the presses can give you very reliable data on the performance to be expected from them as can most other equipment manufacturers. The way to start balancing is to make a list of the parts entering into the product together with the quantities of each, and then determine the rates of production necessary for each series of operations or, as the various series are usually called, production lines. The production rates may derive from the over-all plant capacity, the delivery schedules, a key machine, or the economical lot sizes. There are various ways of expressing production rates, such as tons, pieces, feet, or barrels per unit time, or combinations of these units such as piece-tons. Different have different units and try to standardize them for the purpose of comparing performance. This is not always good. The ton is undoubtedly the best unit for expressing the output of a steel mill, but when the business is expanded to include fabrication this may no longer be true. For instance, in the fabrication of agricultural implement shapes, the shearing time is often greater on the small pieces than on the large ones, and the capacity of a plant to produce tons is entirely different from its capacity to produce pieces. It has been argued that it will average up each month, but a detailed analysis of such a plant showed that this was not so. It struck a reasonable average each year, but the monthly figures were away off. Cultivator shovel blanks took approximately the same shearing time as moldboard blanks yet they weighed about 1.5 lb. against about 20 lb. for a moldboard so, when shearing moldboards, the shear line capacity in tons was about thirteen times as great as when shearing cultivator shovels.

Balancing the Line

The first thing to do, then, is to determine the units in which the production rate is to be expressed and then determine its value. As an example, let us assume we are going to balance a vacuum tube assembly line. The speed of this line or rate of production will be determined by, let us say, the Sealex machine. This is a complicated machine for sealing and evacuating the tubes. For the particular tube we are working on let us assume that the Sealex machine will operate at 600 per hour or 10 per minute. Previous to sealing, the various elements in the tube must be assembled or mounted. This is a hand operation performed by girls. A preliminary experiment showed that it took a girl, reasonably skilled and working at a comfortable rate of speed, about 5 min. to mount a tube ready for sealing. Since the Sealex machine required 10 mounts every minute or one mount every $\frac{1}{10}$ min., it would take 50 girls to keep the machine going. During an experiment, however, we notice that a great deal of time is lost by the girl in changing tools and positions and reaching for the various parts required in making the assembly. The thought naturally occurs to us that perhaps time can be saved by having several girls work in tandem, each one doing a part of the assembly, passing what she has done on to the next one, etc. We examine the operation carefully and find that it readily lends itself to such a breakdown, and therefore we place 5 girls side by side and let them try it that way. The result is very gratifying, but again we notice that 2 of the girls seem to be the bottlenecks; therefore we watch carefully and decide to take part of their job away and give it to the following girl who completes hers ahead of time. This only moves the bottleneck on to the next girl, who is then behind. The next thing we try is using 7 girls and giving the 2 extra ones part of the job that delayed the 2 in the first instance. It seems to work all right now. The balancing of this part of the line is complete, but how about the Sealex machine? How fast can these 7 girls make the assemblies? We run a few tests on that and find that while working at a fast clip, they make about 33 mounts every 10 minutes but, when the pace is more comfortable, they make about 27. It seems too much to expect them to keep up the 33 pace all day even though their skill will increase as they get used to it, but the 27 rate seems fair and the girls agree to it. Next let us try a whole day's run. At the close of the day the over-all rate is 28.1 per 10 minutes including all rest time, but these are all very nice girls and they are trying to do their best; and we know that there will be times when they won't feel well or do as much because of boredom with the monotony of things, so let us not tax them to their utmost. We shall therefore count on only 25 mounts per 10 minutes.

If we install 3 lines of 7 girls each, the rate of production will be 75 mounts per 10 minutes or 7.5 per minute. This won't keep the Sealex machine going so let us try 4 lines of 7 girls each. This will give us 100 mounts per 10 minutes or 10 mounts per minute, which is just what the Sealex machine requires.

Time Studies

The above example illustrates the preliminary balancing of hand and machine operations, and although the figures used have not been taken from any specific example, they are illustrative. In the balancing of an already existing production line, the process is a little more elaborate and requires accurate time studies. In observing the actions of the girls working we, of course, were really making a time study informally. When the preliminary balance is complete, and when the line is actually functioning, exact time studies should be made to try to discover ways of improving it and of determining accurate standards for judging performance and setting incentive rates of pay.

It is usually much easier to balance all-machine production lines because fatigue is not as important a factor, and the rates of production are usually functions of the speed of the machine. During the war production rates were usually determined by the maximum capacity of the plant, but, now that the war is over, this condition may be expected to give way to the more normal situation of production for use and the master delivery schedule will, to a large extent, determine the over-all rate.

Tools

Not, by any means, the least important phase of processing is *tooling*. By this I mean the acquisition of all the implements for making the product. The larger tools, such as machine tools, punch presses, rolls, furnaces, etc., are generally referred to as facilities although this is a very loose term and can be made to include everything. The usual classification of tools is as follows:

1. Facilities
2. Jigs and fixtures
3. Small tools
4. Hand tools

Another chapter will deal with the selection of facilities so we will concern ourselves here primarily with jigs, fixtures, and special tools. It seems hardly necessary to say anything regarding the necessity for tools, but sometimes things taken for granted are not fully appreciated. I should like to ask you to perform a silly little experiment so that you will fully appreciate the value of tools. Don't just think about it or imagine you are doing it, but actually *do* it.

Procure three pencils that have never been sharpened. Take the first one and sharpen it without any tools at all. It is quite a job—as you will see. Next take your pocket knife. (No! Don't sharpen it first.) Put a point on the second one. That will be much easier, but, unless you are an old pencil sharpener from way back, it won't be too good a job. Now take the third pencil, stick it in your pencil sharpener and turn the crank, unless you are trying to compete with me for being the laziest man in the world, because I have a motor on mine. If so, flip the switch. Time yourself in sharpening each one. Now take three blank cards from your card file, and write on each the lettering shown in Fig. 5.

Lay the pencils on the appropriate card, as shown, fill in the blanks, and think about it for a minute or two. It makes a whale of a difference which way you do it, doesn't it? You have probably already thought something like this. "That experiment was very interesting but somewhat of an exaggeration." Believe me, the reverse is true. It doesn't begin to tell the whole story.

The very essence of modern manufacturing is tooling, and in designing your process get the best help and advice you possibly can. America today is the foremost nation in mass production, and this is almost wholly due to the superior quality and performance of our tools. When this statement is made, and it often is, people usually think reference is made to machine tools only, and someone always brings up the Swiss jig borers. It is true of all our tools in general, Swiss jig borers notwithstanding, but more particularly is it true of the tools everyone doesn't see—the jigs and fixtures.

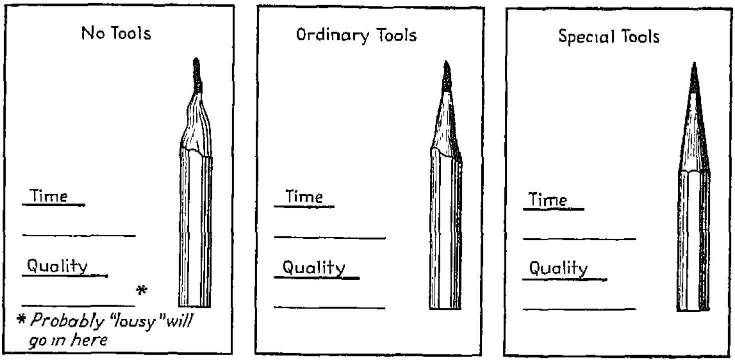


Fig. 5.

Jigs and Fixtures

At this point let us do a little defining. Jigs and fixtures are almost always spoken of in the same breath, and there are many people who think they are just two different names for the same thing. A jig is a tool that clamps the work and guides the cutting tool; whereas, a fixture positions the work while it is being processed by other tools. The most familiar example of a jig is a plate with accurately spaced holes in it that is fastened to the work or vice versa. Drills are then inserted through the holes that guide them and assure proper spacing. An example of a fixture is a positioning device for welding. The various pieces to be joined are clamped to it, and it is turned until the joint is in the most convenient position for the welder.

American Tool Designers

The ingenuity and originality of our American tool designers in devising special jigs, fixtures, and methods are not only unsurpassed in the "old country," but the Europeans are not even a close second. They are all right at propaganda, though, and how often have you heard the virtues extolled of the real old German toolmaker who learned his trade the hard way on the other side. I have had occasion to look into this, and I find it is all a myth. I will take a good Yankee toolmaker any day in preference to a half dozen Germans, Swiss, or men of any other nationality, and the Yankee will make them look like slow moving pictures to boot.

Good tools cost a lot of money, but they will make a lot more than they cost. Labor costs are up to stay in spite of all our wishful thinking, and we might as well accept that fact now rather than have it rammed down our throats later on. Many manufacturers think of tools as devices to eliminate labor. That is the wrong way to look at it, and when this philosophy is accepted you can expect union trouble. I prefer to think of tools and mechanization as means of employing labor to better advantage. I know of no instance where good tools and better mechanization has resulted in a smaller pay roll. The net result usually is lower selling prices, larger quantities, shorter hours, larger pay, and greater profits.

Special Facilities

The matter of specially built facilities often comes up in considering tooling. Each case must, of course, be decided on its own merits, but as a rule, if the quantities are large enough, they pay in the long run. Think of the pencil sharpener. You don't have to sharpen many pencils for that to pay and *well* too. The automobile industry is keenly aware of the value of special facilities and extremely expensive ones in the bargain. I have heard of instances where nearly a million dollars has been spent for one tool. It costs ten million dollars to install a continuous, hot strip mill for steel yet the owner of one can roll strip at such a small fraction of the cost of any other type that it isn't funny.

Tool Design

By the proper design of tools, many operations may be combined eliminating rechucking, repositioning, and handling. Inspections may be made more accurately and faster, and operations that cannot be performed at all without fixtures are made comparatively simple with the proper ones.

All tooling should be determined before making the final process charts so as to take advantage of the ingenuity of the tool designer, and the Product Engineers should work very closely with him.

This can result in many economies if the product designer is ever conscious of the problems of tooling, since he can avoid expensive and unnecessary operations without detracting from the appearance or functioning of the product itself. I have known many instances where collaboration between the product engineer and tool designer has resulted not only in reducing the cost of manufacture but in improving the product design. In one instance I was designing a product and wanted to include a certain operation, but I was afraid of increasing the cost. I called in the tool designer, and, after thinking about it for a day or two, he devised an ingenious fixture that not only enabled us to use the operation in question but resulted in a substantial saving by so doing.

There has been a tendency in recent years to slight tool design, and I feel this is deplorable. Many companies hire young and inexperienced tool designers because they can get them for less money than the older heads. Although I do not want to detract in any way from the virtues of youth, I do want to call attention to the fact that there is no substitute for experience, and the few extra dollars spent to get a good ingenious tool designer will be more than repaid in a very short time.

A word of caution about the "old guys" is not amiss. Beware of the kind who, "Man and boy, have 'sailed the seven seas' these 40 year." I mean the kind who, instead of having 40 years' experience have had 1 year's experience forty times. They are really worse than the young lads. There are lots of good tool men to be had but, remember this, if they are really good you can't get them cheap and it is a mistake to try.

IN PROCESSING YOUR PRODUCT	
DO	DON'T
1. Start with a chart 2. Record the know-how 3. Make lots of drawings 4. Balance all lines carefully	1. *Don't* be reluctant to change 2. *Don't* depend on memory 3. *Don't* use meaningless units 4. *Don't* slight tool and fixture design

CHAPTER IV

SELECTING THE FACILITIES

The best is none too good.

SELECTING THE FACILITIES

BY *FACILITIES* I mean, as explained in the previous chapter, the large tools. This subject has been rather completely covered from all angles in various works, and a prodigious number of formulas have been worked out for the guidance of the engineer in the selection of machinery for new processes and replacement. Let us leave those rather intricate determinations for the equipment engineer with a comment or two on intricate formulas in general.

Formulas

Personally, I don't like intricate formulas. I don't like formulas of any kind unless I am completely conversant and familiar with their derivation. There has been a tendency throughout the last 25 years for engineers to make more and more formulas of gradually increasing complexity, and sometimes I am convinced that they are trying to follow in the footsteps of the medical profession or the law. These two worthy professions conduct a great deal of their business in Latin leaving the layman completely mystified. They seem to feel that the less the client knows about the details of their machinations the more willing he will be to go on paying their bills, and this is probably true for the less competent among them. I think engineers, however, would do well to adopt the opposite approach. There is no mystery about engineering, and I think the client as a rule is more willing to pay for something that he can understand than for a lot of hocus-pocus and legerdemain. If he wants to see miracles, he will go to a vaudeville theater where Zilch, the Great, will saw a woman in half for the modest sum of $3 plus tax.

Capacity

Having vented my spleen on the formula boys, let us get on with the business of selecting the facilities or machinery, if you prefer the term, for our new production line. A good place to start is with the operation sheets. Study these with care and list all the various kinds of operations that have to be performed. Consult with both the Product Engineers and the Tool Engineers to determine the particular kind of tool or machine that will be needed and carefully determine the needed capacity. Don't buy any *more* capacity than you need. Run your machines to their full rated capacities and don't baby them. If properly lubricated and maintained, they will be obsolete long before they wear out.

Salesmen

Talk to all the equipment salesmen. With very few exceptions, they are good honest fellows, and you can learn a lot from them. They will keep you posted on all modern improvements and can very often show you a wrinkle or two that you couldn't find out any other way. It is their business to see that you get the proper machine for the job, and if they neglect to keep this in mind, they won't last long. Be a little wary of the machines that do everything. They are good for an experimental laboratory, where you never know today what you will be called upon to do tomorrow, but they rarely perform efficiently on a production line. A machine that will do everything will probably do nothing well. If you sharpen pencils with your razor, you can't expect a velvet smooth shave, even if you do use Barbasol, and what happens when you spell the name of the machine backwards is not of transcendent importance.

Attachments

Try to select machines that will do well exactly what is called for by the processing and do it in the time allotted, no more, no less. Someone will always advise a little excess capacity or a gadget or attachment that will do something besides what is called for, and they will say, "You never know when you will want to do this, and if you have the machine, you always can." Remember that until you do want to do it the extra gadget is sheer waste as are the fixed charges incident to its extra cost. Never buy a universal milling machine for a job where a plain miller is all that is needed even though you think that some day you will no longer be making gadgets but will be in the widgit business, and widgits will require a universal miller.

Another reason for not having machines on the production line with "added attractions" on them is that someone is always wanting to use the machine so endowed for a special job that will only take a minute or two.

Case VIII—*The Case of the Giant Shear*

One of my clients had a shear line in which one of the shears was of extra large capacity, and about once a week there was a special job to be done which that shear could do. Invariably they stopped production and did the special job. That meant that the other seven shears were idle while the big one did the job, and production ceased. A record kept over a period of time showed a considerable loss of production although the stoppages were of comparatively short duration. I finally convinced them that it would be more economical to purchase a small shear for the line and put the big one in the job shop. The elimination of the stoppages and the increased use of the big shear paid for the little one in less than a year.

Furnaces

The selection of furnace equipment is something you have to be very careful about. There are more old wives' tales about furnaces than anything else I know of. There are still a great many furnace manufacturers who are so steeped in tradition that they are today making furnaces that were obsolete before the turn of the century. These people will arrogantly assert that a modern continuous furnace just won't heat this or that material and that their experience and that of their forebears, principally the latter, demonstrates the utter impossibility of it. They won't even admit it when they see it but will just make a few unintelligible grunts and walk away probably thinking terrible thoughts about the heresies connected with these newfangled gadgets. They still find customers, however, in the old established industries whose superannuated "mossbacks" are far more interested in maintaining the *status quo* than in making a profit.

Material-handling Equipment

Although the procurement of material-handling equipment should not be begun until the layout has been completed, it is perhaps fitting that a word or two about it be said here. There are literally hundreds of companies making this class of equipment, and a great deal of it is good. It covers an enormous range all the way from giant cranes to tiny conveyors that move the minute parts going into watches and vacuum tubes. There are two main classes of material-handling machinery besides good and bad. They are the kind that move material in batches and the kind that move it continuously. The process will often demand one kind or the other, but where there is a choice, I have always preferred the continuous type such as a belt or slat conveyor or some modification thereof. The use of continuous conveyors, as a rule, reduces the inventory of work in process by removing the delays incident to awaiting an operation or to awaiting removal in tote boxes or piles on the floor. Of course, it is not always possible or practical to use continuous equipment, but the idea of using it should not be abandoned until its impracticality has been demonstrated beyond question of a doubt. If material must be moved in batches, tier trucks offer one of the best answers. They are excellent for handling stacks of plates and tote boxes on skids. The layout should provide for truck handling, if adopted, by leaving wide and unobstructed aisles.

Positioning

An extremely important consideration in all forms of material-handling equipment is the maintaining of position in the material transported. If the machine operator has to twist and turn each piece of material he handles to position it correctly for processing, a great deal of time can be lost. If the material-handling machinery can be designed so that each piece is presented to the operator in such a way that a minimum of change in position results, nearly all this loss may be saved.

Case IX—*The Case of the Tumbling Logs*

An interesting case in point has just confronted a client of one of my associates. This client makes wood veneers. The process is one in which logs varying in size from 6 to 40 in. in diameter are cut to length with a crosscut saw, are classified as to size, and then are soaked in warm water for from 18 to 24 hr. They are then delivered to the veneering lathe to be processed. The usual practice in the industry was to sort the logs for size and drop them helter-skelter into tanks of water containing metal baskets. At the end of the soaking period, the logs were brought to the lathe and each had to be positioned. Preliminary analysis of the process showed that as the logs came from the crosscut saw they were all positioned and might, were it not for the necessity of size classification and soaking, be brought directly to the lathe. They talked the matter over and decided to try to retain this positioning throughout, since it is a sizable job to reposition large logs. The solution arrived at was as follows: The logs were taken from the saw moving axially on a chain conveyor having a series of V-shaped saddles or flights attached to it to keep the logs from rolling off. Chain and logs passed through photoelectric inspectors, which first pushed off the larger classification at right angles to the chain and then the next size, etc. The logs rolled down and entered long shallow tanks, one tank for each size classification. Running over the top of each tank was a chain conveyor to which were attached flights consisting of a series of bars like a comb. As these bars came along the top of the tank, the points stuck up in the air, but, when they turned the sprocket where the logs came in, the points went down into the water, each set carrying a log before it. Each chain moved only when a log rolled down, and the logs were held under water by the weight of the chain and combs. During the cutting period the tanks were filled with logs, and at the end of the soaking period one tank would be cleared at a time. The chain would move one space, and the comb would discharge a log onto a conveyor similar to the one from the saw to the tanks. In this way all the logs of a size classification would be delivered to the lathe as they were needed, eliminating both further positioning of the log and changing the setting of the lathe. I do not remember what the total saving was in money, but I do know that it was a substantial percentage of the total cost.

Positioning is very important in the garment industry, but few garment makers seem to do anything about it.

Case X—The Case of the Twisted Girdle

From the window of my office I can see a girl operating a sewing machine in a local garment factory. I cannot see how the pieces come to her although I can see what she does with them when she picks them up. She seems to be sewing some kind of girdle and every piece has to be turned through an angle of 180 deg. before she can start on it. When she finishes a piece, she tosses it, willy-nilly, onto a pile that is out of sight, but I suppose the next operation has to position it all over again. As a rule I don't go very hard for time studies unless they are necessary, but I couldn't refrain from checking this operation. She spent an average of 21.2 per cent of the operation time positioning the work.

Used Machinery

Now a word or two about used machinery. There is, and always will be, a lot of good, used equipment on the market, but for every good tool there are a thousand bad ones. I would never recommend the purchase of a used machine unless I knew something of its history. Reconditioned tools are in the same class, and one must be sure the reconditioning was not done entirely with a paint brush.

The three principal reasons for used tools being on the market are as follows:

1. The tool is worn out.
2. It is obsolete or broken.
3. The original owner did not need it longer.

Tools that are worn out, obsolete, or broken are usually the ones that are resold as reconditioned, and some people think they are saving money when they buy this old junk.

Case XI—The Case of the Vulcan's Forge

I know one manufacturer who wouldn't spend a dime for good tools, but who buys all the old junk that comes

> on the market. He is number one on all the junkies' "sucker lists," and his plant looks like a dirty museum. When you go in you expect to see Vulcan flutter down from the rafters at any minute. He is distinctly a marginal producer, and as soon as postwar competition hits him, he will be gone with the wind.

Selling scrap to the Japanese before the war was not a very smart thing, but it certainly did American industry one service. It put a lot of the old junk from the bone yards on Center Street into the open hearth where it belonged and kept shortsighted manufacturers from spoiling their production lines and thus impeding the war effort. It is a pity a lot more of it didn't go into our own open hearths.

Tools that the original owner did not need longer are the only ones worth considering, but you should have them checked and double checked by someone who knows what it is all about before putting any of them in your line.

In closing this chapter, let me caution you to remember what Squibb & Company say in their advertisements for it is indeed a great truism. "The priceless ingredient of any product is the integrity of the maker."

IN SELECTING YOUR FACILITIES

DO	DON'T
1. Study the requirements	1. *Don't* buy excess capacity
2. Study the markets thoroughly	2. *Don't* buy gadgets
3. Buy only what you need	3. *Don't* buy junk
4. Use all you buy	4. *Don't* trust bargains

CHAPTER V

MAKING THE LAYOUT

The layout is the skeleton of the process.

MAKING THE LAYOUT

THE first step in making the layout should be a comprehensive study of the process and flow charts that we evolved in Chap. III. These are, or should be, a graphic representation of the process itself, and the layout should be the expression of the process in terms of the various physical units in it. The layout, as well as the process charts, should be an evolution and cannot be arrived at all at once.

There are two methods of laying out or grouping the various events in the process, and both have their advantages and disadvantages. They are called by various names, none of which is completely satisfactory. "The Production Handbook" calls them "The Process Layout" and "The Product Layout." I prefer the terms "Jobbing Layout" and "Line Layout." The process or jobbing layout groups all similar machines, and the product or line layout places the machines along the line of travel of the product or part. The diagrams in Fig. 6 and 7 reproduced from "The Production Handbook" will serve to illustrate the two principles.

These diagrams show the flow of two parts through a factory laid out both ways. A table of the advantages and disadvantages of both methods is given in "The Production Handbook," and there doesn't seem to be any point in reproducing it here since anyone interested in the minutiae may obtain this valuable book almost anywhere.

Where production will consist of a large number of parts in relatively small quantities, all processed differently, the jobbing layout offers more advantages, but where the number of parts is less or the quantities are great the line layout is more efficient. When the plant is running at low capacity, the jobbing layout will produce at less cost, but when it can run at anywhere near full capacity the line layout will be the best.

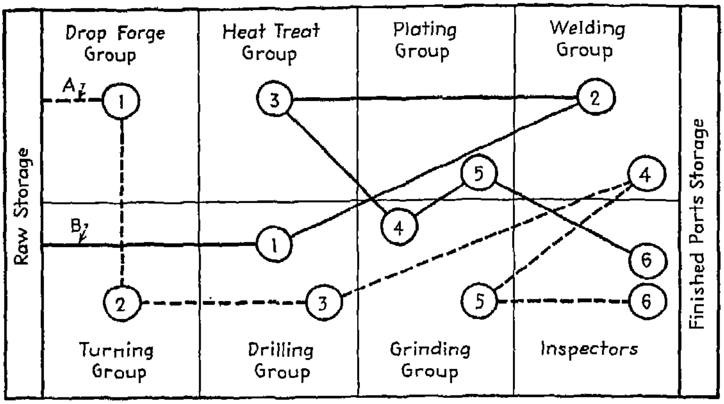


FIG. 6.

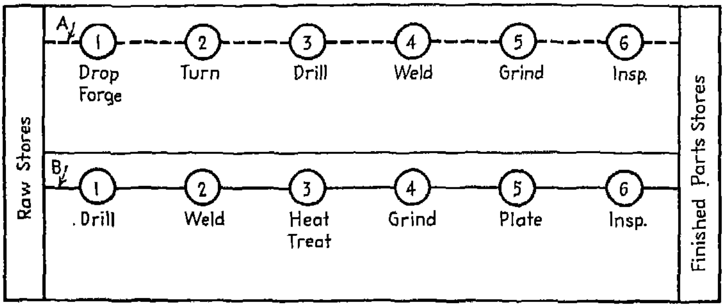


FIG. 7.

The line layout requires a smaller inventory of work in process, entails less material handling and shorter travel, and involves less delay. It lends itself more readily to the use of unskilled labor and requires less than $1/10$ of the paper work necessary for control. This last saving is the one that appeals to me more than any other since all paper work is, at best, only a necessary evil, the efficiency experts notwithstanding. The line layout may be slightly more expensive to install because there may be some duplication of machines, but I believe this will be more than offset by the shorter time of production and the saving in floor area. All in all, I recommend a diligent effort to adapt the process to the line layout method if it can possibly be done.

Having decided which method will be used, the next step is to start with the actual layout. This should be done one line at a time and then the various lines should be arranged so that they feed the assembly line most efficiently at the points the parts are needed. Try to minimize finished parts storage as much as you can by trying to get better balances in the various lines. In laying out a line, keep it straight as long as you can. You will undoubtedly have to bend most of them eventually, and there is nothing detrimental in that, but don't do it until you have to.

Paper Doll Technique

A good way of arriving at the line layout is called the "paper doll" method. It consists of cutting out pieces of cardboard roughly in the shape of the various machines and at some convenient scale. The larger the scale, the better in the beginning. A good scale for the individual line layouts is ¾ in. = 1 ft. – 0 in. because it is large enough so you won't need your reading glasses, and it is convenient to measure with an ordinary ruler. On this scale $1/16$ in. = 1 in. and 3 in. = 4 ft. – 0 in. These cutouts or templates are usually called "paper dolls," and if you hear some draftsman, even the Chief or Process Engineer, shouting loudly that some "crook" has "swiped" his paper dolls you need not be concerned about his sanity.

Don't make your layouts "tight"! Keep them open, but don't waste space, and always keep in mind how the material is going to get from one machine to the next. If you are using the jobbing layout, make sure you provide adequate space for storage of parts awaiting process or removal so these won't pile up in the aisles. I have been in many a plant where you had to climb over tote boxes full of castings or swing from the ceiling joists to get from one end to the other, and there is no excuse for this at all.

When you have the paper dolls representing the various machines arranged and pinned down where you think they belong, take a soft pencil (6B) and draw around them. Then take them off and write in what each machine is. Cross hatch each machine with a red pencil and each hand operation or bench with a blue one. Now indicate your fixed material-handling equipment and hatch that with green or some other color, and show the material flow with a black line and arrows. Then put the line away for the time being. Do each line in the same way. Finally do the assembly line, marking on it where each of the other lines come in.

The Esquisse Esquisse

Now take each line and make a paper doll of it at a reduced scale, say ¼ or ⅛ in. to the foot, show on each one the machines, the hand operations, and the material-handling equipment. Place the assembly line in the middle of the drawing board, and arrange all the production lines so that they terminate at the proper point on the assembly line. Draw around these, pick them up, and label the component parts. That is your preliminary layout or, as the architect would say, your *esquisse esquisse,* meaning, they tell me, a sketch of a sketch.

The Building

We must next give some consideration to the building that will house the layout. Will it be a one-story building or a multistory one? Will it be a new building that we can tailor to fit our needs, or will it be one we already have? Perhaps we will want to buy a building wherever we determine to locate our factory. Let us hope we can build one that is "just what the doctor ordered," but, if not, we will have to do the best we can with whatever is available to us.

Single vs. Multistory Buildings

I want to say a word or two about the relative advantages of single and multistory buildings. If the enterprise can be located in an area where the cost of the land is not prohibitive, there are many advantages to be had from a single-story building. *First,* it takes much less time to erect and will probably be much cheaper per square foot. *Second,* the problems of internal transportation are usually much simpler since vertical movement is unnecessary. *Third,* much heavier floor loads can be accommodated without the expense of heavy structural members, and light and ventilation can be better throughout the building.

The only cases in which the multistory building possesses advantages are where the cost of land is very high and where gravity flow of materials is required, although sometimes the topography is such that entrances may be placed at different levels and some advantages may accrue therefrom.

For the moment, let us assume we are going to build a new building and let us see how we should go about it.

Our *esquisse esquisse* should give us some indication of what we will require. Suppose it looks something like Fig. 8:

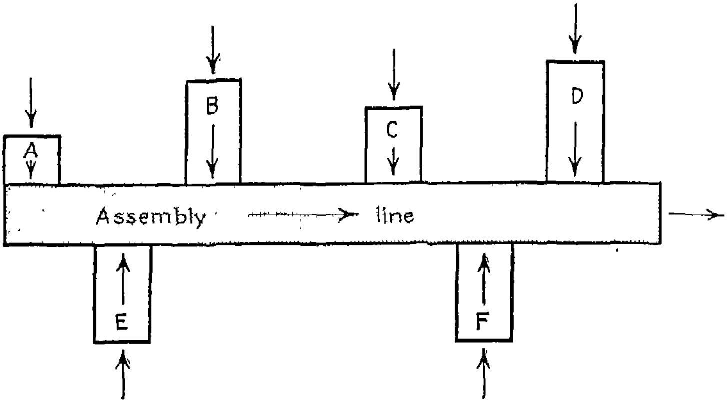


FIG. 8.

Perhaps we can do something as in Fig. 9 with it, or, if the assembly line is longer and the feeder lines more numerous, we might even turn the whole thing around a corner, making the building in the form of an L, a U, or an E, with the assembly line in the vertical member:

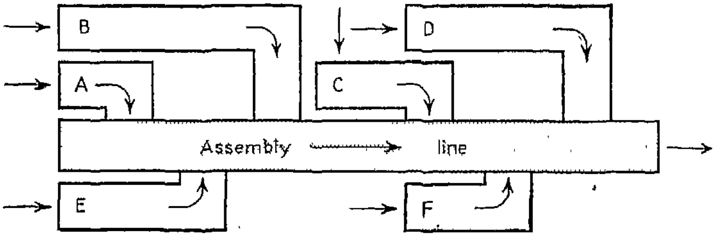


FIG. 9.

If the assembly line is short in relation to the production lines, it might run the short way of the building and the production lines run the long way:

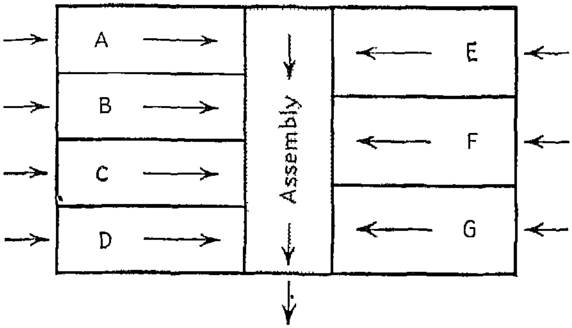


FIG. 10.

It might even be in the form of an H, as in Fig. 11,

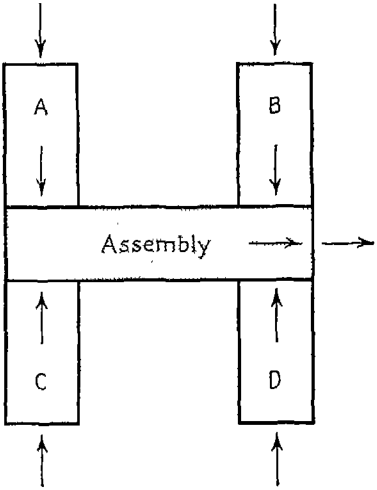


FIG. 11.

or an H with intermediate legs, as in Fig. 12:

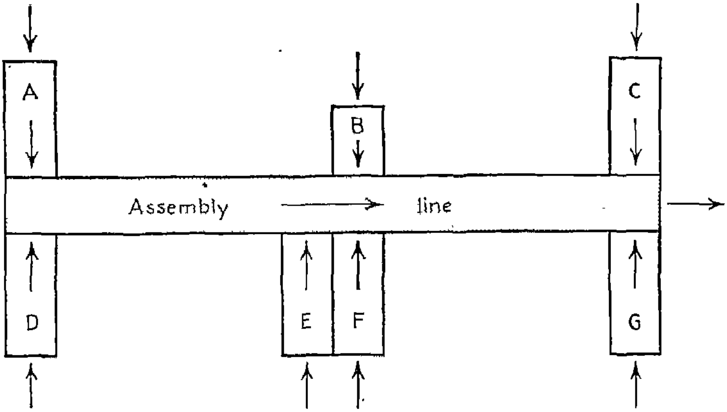


FIG. 12.

There is really no end to the possible ramifications, and the big trick is to choose the right form to accommodate the process and provide for future expansion without undue expense. It is a good idea to try to foresee any expansion, where it is apt to come, and if possible, how great it will be. A little thought in this may save many headaches later.

Existing Buildings

If it will be necessary to use an existing building, the technique is slightly different. Make a drawing of the building on heavy detail paper to the same scale as the *esquisse esquisse*. Locate all columns, stairs, windows, doors, and other permanent features and then, using the second group of paper dolls, those showing the complete lines, start to fit them in. When you come to a point where you have to bend a line, do not cut the doll in half but make a new one bent at the proper place. You should keep the originals intact for you never know when you may want to start all over again. You usually do this about nine times before you really get going.

Building Services

Once you have determined the general idea, you can begin to go into detail, but be sure you have allowed adequate space for toilets, rest rooms, aisles, shop offices, and production control points. Be sure your circulations† are wide and numerous enough and then increase them by half again as much and you will be only slightly undersize.

When you have thought of everything you can and made provision for a number of things you have undoubtedly forgotten, unless you are superhuman, start the final drawing. Use as large a sheet of detail paper as you can, and make the scale as large as possible also. Draw the entire process and the building on the same drawing, and *show everything!* Don't leave anything to the imagination, for it is much cheaper to make changes in the drawing than it is later when the work is two-thirds finished and one-third has to be ripped out. Years ago when I was working as a draftsman an old carpenter came to the drawing office one day to call attention to a mistake in one of the plans. He said, "There's no justice in things any more. All you draftsmen got rubbers right on the end of your pencils, but nobody ever gave me a saw with a rubber on the end of it."

Expert Advice

I would strongly advise seeking the advice of those experienced in layout work not only because of the difficulties involved but because of its extreme importance. A great deal of my business consists of trying to correct the mistakes of inexperienced people who have tried to go it alone, and I am sure the same applies to other consultants. An ounce of prevention may save a lot of grief.

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† Halls, aisles, doors, stairs, etc.

IN MAKING YOUR LAYOUT

DO	DON'T
1. Study your process thoroughly	1. *Don't* make the layout tight
2. Select the right type of layout	2. *Don't* skimp on the circulations
3. Make plenty of sketches	3. *Don't* forget the building services
4. Show everything on the final drawing	4. *Don't* be in too big a hurry

CHAPTER VI

CHOOSING THE LOCATION

Is welcome on the map?

CHOOSING THE LOCATION

IF THE enterprise is a new one, perhaps the first thing to determine is the general location. There are several factors that enter into the choice, and the principal ones are

1. The availability of labor
2. The cost of delivery of the raw material
3. The cost and convenience of shipping the products to the market
4. Accessibility
5. Climate

Availability of Labor

The things to bear in mind regarding labor are whether or not an adequate supply exists in the immediate vicinity, whether this labor will be available at a reasonable cost, whether it is the right kind of labor possessing the needed skills, or whether it is trainable in a sufficiently short time. The nature of the enterprise, of course, has a great deal to do with the situation. If it requires a large number of untrained girls possessing only reasonable manual dexterity, a different location may be required than if it is a tool and die shop where skilled mechanics are needed.

The local labor unions and their record in dealing with employers should be carefully investigated. Any history of unreasonableness should be looked into thoroughly. Many labor unions are fair and reasonable, whereas others are quite the contrary.

Shipping Costs

The second and third items refer to shipping costs, and a careful study should be made to avoid an unfavorable differential. This is especially true if the materials and products are heavy and move in large quantities. Making a tabulation similar to that shown in Fig. 13 can be of great help in determining all shipping costs in advance.

If such a tabulation is made out for each area under consideration, their relative advantages will be immediately apparent.

Accessibility

The fourth item, accessibility, varies in importance within rather wide limits. The shipping cost tables may show that it is extremely important to have the plant located near the source or sources of raw material or it may show that savings may be realized by having it close to the principal market. On the other hand, it may be that proximity to either is not a factor if the plant be located somewhere between them.

If the general office is to be located at the factory or plant, accessibility to a good residential district is essential for the executive and supervisory personnel. If the general office is to be located elsewhere as, for instance, in a large city, the accessibility of the factory to the office may be important. The amount of supervision required by the general executives is the factor that should control. It must be remembered that the time of these top executives is valuable and limited so it should not be wasted in unnecessary travel.

MATERIALS AND SUPPLIES								
Item no.	Material	Wt. used per year	Shipping, lots	From	To	Via	Rate	Yearly cost
1								
2								
3								
Total materials and supplies........................								$
PRODUCTS								
Item no.	Product	Wt. shipped per year	Shipping lots	From	To	Via	Rate	Yearly cost
1								
2								
3								
4								
Total product...............................								$
Total materials and supplies........................								$
Grand total................................								$

FIG. 13.—Shipping cost table.

Climate

The last item on the list is climate and, although this is usually not as important as other considerations, it can be the controlling factor. The original cause of the migration of the motion picture industry to southern California was the favorable climate. However, with modern heating and air conditioning equipment as well as improved lighting facilities, climate is not as large an element in location choice as formerly.

Many industries have special peculiarities that must be taken into account. Some food processing industries, for example, have to be near the source to prevent spoilage and others have an acute problem of waste disposal or water supply. These special factors often assume such importance that they eclipse all other considerations, and they must be carefully studied before deciding on a location.

The Site

Once the general location has been decided upon, the next step should be the selection of the site. This, of course, hinges largely on the decision made as to the type of building that will be used. If it is to be a new building, suitable property will have to be found and a good real estate agent can be of great help. Real estate agents generally specialize to some extent, and it is well to seek one out who specializes in, or at least has had some experience with, industrial properties. He will be familiar with the zoning regulations and other ordinances which have jurisdiction, and he will also know most of the available property.

The Lot

The size and shape of the property will be determined by the layout. At any proposed site you will want to investigate the availability of transportation, both for the raw materials and the finished products, as well as its accessibility to employees and others. Do not handicap yourself by building a factory that is difficult for the employees to reach because you will have to take either second choice of the available talent or provide some form of transportation for them. Look into the availability of services such as water, gas, and electricity, as well as sewage disposal facilities, and, if you have any unusual requirements in this regard inherent in your process, be sure the distribution system of the utility company is adequate to take care of your needs. If you have a steam power plant, be extra sure of the availability of condensing water the year around.

The Entourage

Try to select as pleasant a location as possible, one that will lend itself to good landscaping with a minimum of expense, and be sure to get enough property. Remember that the real estate expense is one of the smallest items of the total expense, and don't "skimp." Also bear in mind that the time will surely come when you will want to expand your plant, and you can probably buy enough property in the beginning to take care of this expansion for very little extra cost; whereas, if you wait until the time comes when you need the land, the owners will either know you want it or will have some other plans in mind for it, and you will pay a fancy price to get it.

If you have to buy a building, the layout will not have been finished at this point, and the thing to do is to have the real estate agent locate a few likely ones. If, after inspection, you feel that any of them have possibilities, draw plans of the floor space to the same scale as the *esquisse esquisse*, and try to fit the layout into them. If this can be done without too much alteration of the layout, after leaving enough space for service facilities and offices, this building will probably do provided that it meets all your other requirements. However, I repeat, *don't get the layout tight!*

IN CHOOSING YOUR LOCATION

DO	DON'T
1. Investigate the availability of labor	1. *Don't* locate where you are not wanted
2. Investigate shipping costs	2. *Don't* ignore employee transportation
3. Investigate general accessibility	3. *Don't* skimp on land
4. Investigate climatic conditions	4. *Don't* forget utility services

CHAPTER VII

HOUSING THE ENTERPRISE

Let us be proud of the
house in which we live.

HOUSING THE ENTERPRISE

THE primary purpose of the building is, of course, to protect the contents and personnel from the elements, and the degree of protection required will determine, to a large extent, the nature of the building. There are many factors entering into this determination such as climate, the nature of the process, etc., and the result is a very wide range in types of building in every locality.

Case XII—*The Case of the Wooden Umbrella*

> In Azusa, Calif., the American Cyanamid Company have a plant making hydrocyanic acid. The climatic conditions are such that protection from the rain is all that is necessary, and the building housing the acid generators consists simply of a roof with no side walls at all.

Case XIII—*The Case of the Naked Gas Plant*

> The Consolidated Edison Company built a unit at their enormous gas plant at Hunt's Point in the Bronx in which the process was such that no building at all was necessary, and the only structure used was that needed to hold the machinery up.

Both of these plants required little or no attendance so protection of personnel was not a factor.

The opposite extreme is found in plants where it is not only necessary to protect the personnel from the weather, but where even the outdoor weather is not good enough and elaborate air conditioning is necessary.

Case XIV—*The Case of the Delicate Hose*

> An example of this is the Archer Hosiery Mills in Columbus, Ga., where an extremely high grade of ladies' full-fashioned hosiery is made. The delicate yarn used in knitting hosiery is hygroscopic and expands or contracts with the changes in humidity. Therefore, it is necessary to maintain accurately controlled conditions of temperature and humidity in the plant.

In plants machining metals to extreme accuracies and close tolerances temperature conditions must be accurately maintained to prevent serious errors that may be caused by expansion or contraction of the parts and of the measuring instruments.

Lighting

Good lighting is enormously important in any plant, although there is a tendency in the heavy industries to ignore it almost entirely. Even if windows are provided originally, they are never washed, and they soon become as translucent as a stone wall. Others go to the opposite extreme and build plants that seem like one huge window bent around the corners and covered with skylighted monitors or "saw tooth" roofs. I like this type. The plants are cheerful and bright, and this condition is invariably reflected in the people who work there. Another "stunt" that has enjoyed increasing popularity of late is to build the plant entirely without windows, all ventilation and light being supplied artificially. I do not like this, unless it is demanded by process requirements, because it makes too complete a separation from nature. I am perfectly willing to admit that man has made great strides in his struggle to improve the conditions under which he exists, but I have never yet seen the artificial light source that can compete with sunshine in satisfying his soul.

Case XV—*The Case of the Missing Sun*

I visited one of these ideally conditioned plants one day, and during the noon hour everyone flocked into the sunshine to eat his lunch, sitting on a rock or a pile of railroad ties although a beautifully appointed cafeteria was provided inside. I was walking across the open space between the entrance gate and the plant at about the end of noon hour and one of the men, in a little group sitting on the grass, stood up, looked at his watch, and said, "Come on, boys, it's time to go back to the mines."

Living Conditions

In designing the building, considerable thought should be given to providing, not only good working conditions, but good living conditions. The effect of good living conditions on employees' morale is enormous, and the pride that they take in their surroundings is surprising.

Case XVI—*The Case of the Cheap Chintz "Drapes"*

Some time ago I visited one of the Sylvania plants located in Brookville, Pa. In this plant, which is a feeder for some of their larger ones, a couple of hundred girls sit at benches mounting vacuum tubes. One of the supervisors, a girl, in showing me around pointed to some inexpensive chintz drapes at the windows and explained how the company left no stone unturned to make their working conditions as happy and comfortable as possible. She said the girls seldom sought other jobs for slight increases in pay because other employers were not as considerate of them in the little things that made so much difference.

Toilets

A vital part of the living conditions in a plant are the toilets. In consideration of this vital phase most manufacturers *think in terms of the factory laws of the state.* They comply with the law, and stop right there. This is most unwise. The law specifies the *minimum* that will get by. There is nothing in the entire factory as disgusting to the worker or as destructive to morale as dirty or odoriferous toilets, yet I have known manufacturers who utterly ignore the dictates of common decency in this regard.

Cement is not a good material for either the floors or walls of toilet rooms. The surface is porous and in a short time odors are absorbed and it starts to smell. From then on it will always smell no matter how carefully it is cleaned. The best material for the walls is glazed tile or glazed brick and for the floors either tile or terrazzo. The difference in expense is not great, and the lowered maintenance cost is considerable.

Locker Rooms

Where there are women employees, the providing of *cheerful and comfortable rest and locker rooms is a must,* and these rooms should be furnished in as attractive and homelike a manner as possible. The women will take great pride in their rest rooms and better morale is always the result of a little care and pains in this regard. It is not quite as important to "doll up" the men's locker rooms as it is the women's, but they should be neat and clean and the lockers should be commodious. Sufficient space should be provided for the men to change their clothes in comfort, and above all provide something to sit on. If you have ever tried to change from your golf clothes to street attire in a country club locker room with no seats in it, you won't need any further urging. The difference between the men's locker room in your plant and that in your club is that the men have to use it every day and you only use the club lockers about once a week. Shower baths should be provided in the locker rooms.

Drinking Water

There should be an adequate supply of clear, cool drinking water throughout the plant. It should not be too cold as is usually the case. In hot weather too cold water is apt to produce cramps, and a man can't drink enough of it to supply his body losses. Some companies supply salt tablets at all drinking fountains, which is a very good idea.

Flooring

Considerable attention should be given to the selection of flooring throughout, since good flooring is one of the greatest aids to efficiency. In the heavy industries and in foundries many plants use dirt floors. I think there is nothing worse for any purpose no matter what the conditions. If there is any walking around to be done, nothing will sap energy more than a dirt or cinder floor and, in some instances that I know of, employee efficiency has been increased between 20 and 30 per cent by substituting a concrete floor for a cinder floor. I do not like concrete floors in shops where men or women are compelled to stand on them all day. They have no give and are inclined to "dust" after a short while. In machine shops a wood-block floor is very good. There is enough resilience to make them comfortable, and they are not as cold as a concrete floor. In shops where concrete floors are provided, you will notice that after a short while machine operators will contrive some way of obtaining small wooden grillages to stand on. If the company provides nothing, they will get it from somewhere themselves.

Linoleum makes an excellent floor, and there is nothing in the world to beat cork tile where it can be used. It has excellent sound absorbing qualities, and the general noise level in a shop using cork tile floors is many decibels lower than in those using other materials.

Heating

Heating and insulation are also important factors. The insulation of ceilings is more important than of side walls, since so much of the side walls is usually taken up with windows. If possible, the insulation of the ceiling should be such that it provides a sound absorbent surface on the inside as well as prevents heat loss through the roof. The purpose of the heating system should be to provide adequate and uniform temperature conditions throughout the plant, and there are so many ways of doing this that I shall not try to enumerate them but leave it for the heating and ventilating engineers that you should employ. I should, however, like to say a word or two about a comparatively new system of heating that seems to have great promise. That is radiant heating. The usual method of application in factories is to imbed pipes in the floors during construction through which hot water is circulated. This maintains the floors at a certain temperature and radiates heat continually upward. It is claimed, and I believe justly, that a considerably lower air temperature may be maintained in a factory so heated with comfort to all the occupants. If this system is installed with a roof insulation having a reflecting surface downwards, the heat losses from the building may be considerably reduced due to the reduced temperature head from inside to out, and the cost of maintaining comfortable conditions can be made extremely low.

Color

Of recent years a great deal has been said and written about colors in industrial plants and a prodigious amount of research work has been done on the subject. Many industrialists are inclined to dismiss all this as pure "hokum."

I want to assure you here and now that it is not hokum nor should it be lightly dismissed. Discount, if you will, 75 per cent of the claims and still you have enough left to warrant considerable attention to the subject.

Case XVII—*The Case of the Colored Lathe*

> I had always been a little suspicious of the claims of the paint experts as regards machine colors, but I tried it out in my own laboratory and was really amazed at the difference it made. The first machine I tried it on was my "personal" lathe, the one that was reserved for me to operate and no one else. I thought I would get some first-hand "dope" thereby and, believe me, I did. I am no expert in such matters since I only know enough about them to appreciate the necessity for expert counsel. Consult a color expert by all means. It won't cost much, and it pays off "big."

The Architect

The last thing I want to counsel you about regarding your building proper is the architect. Be sure to engage a competent architect who has had some experience in industrial work. The subject of plant buildings is a large one and has sufficient ramifications to absorb the entire professional activities of many men. Many architects do nothing but industrial buildings and are familiar with every phase of the subject. Do not make the mistake made by so many people of looking on the architect as an impractical visionary. The profession, or perhaps I should say the art, of architecture is the oldest of all the arts since man's first endeavor, after obtaining enough to eat, was to protect himself from the elements, and from this basic urge grew the profession of architecture. I repeat—get a good architect, and pay attention to what he recommends.

Landscaping

After your building is complete you will have the problem of landscaping your property. Do not neglect this since it can be one of your most valuable advertisements. You do not need to spend a lot of money, but do be tasteful about it. I know so many plants that are beautiful to look at, and then there are others that look like "dumps."

Case XVIII—*The Case of the Beautiful Plant*

> There is a small plant not far from my home. It is The Edwards Company in Norwalk, Conn. It is a never-ending source of pleasure to pass by and see how beautifully it is landscaped and maintained. I do not know this company, but I am told they make some sort of electrical devices, and I am sure they must be good ones, for no company could take such great pride in their factory and be other than meticulous about their product.

The plant does not need to be a large one to be well landscaped.

Case XIX—*The Case of the Well-kept House*

> Take the plant of George Webber, the gauge block maker in Cleveland, Ohio. I don't think he has more than 20 or 25 men yet his little plant is a model of neatness, and once you have seen it you won't forget it.

Case XX—*The Case of the Clean White Coat*

> The C. L. Gougler Machine Company in Kent, Ohio, is an example of the medium-sized plant that is tastefully but inexpensively landscaped. Mr. Gougler takes such pride in his plant that he supplies all of his 1,600 employees with white working coats that are *kept clean.* I told a friend of mine about this one day, calling it the "Gougler Plant," and he said, "That's all right in some places but imagine trying to do it in a

> machine shop. It can't be done." The Gougler plant is one of the largest general machine shops in the United States.

Many people, through years of slovenliness, come to think that dirt is inherent in their process. I suppose it is easier to think this than to think that you are just dirty yourself, but nine times out of ten the fault is with the management, not with the process.

Case XXI—*The Case of the Immaculate Foundry*

> Foundry men have often told me, "You just can't keep a foundry clean." I tell them, "Go look at Crouse-Hinds in Syracuse." There is a large foundry where you could literally eat your dinner off the floor if you were so inclined.

The more pride you take in your plant the more respect others will have for your product.

IN HOUSING YOUR ENTERPRISE

DO	DON'T
1. Provide good working conditions	1. *Don't* put up an eye-sore
2. Provide good living conditions	2. *Don't* neglect your lighting and flooring
3. Engage a good architect	3. *Don't* overlook the effect of color
4. Tastefully landscape your property	4. *Don't* neglect your housekeeping

CHAPTER VIII

DESIGNING THE ORGANIZATION

Let it not be mere mechanism but a true and significant machine.

DESIGNING THE ORGANIZATION

THE dictionary defines an *organization* as an arrangement of interdependent parts, each having a special function, act, office, or relation with respect to the whole. Immanuel Kant says of an organization:

> Each part separately is mere mechanism; it is a true and significant machine only in its relation to other parts, its full significance being determined by the complex whole which the interacting parts create, not as their sum, but as a construction differing in quality from each and all of them.

Hence, an organization may be considered as an exception to the geometrical rule which states that the whole is equal to the sum of its parts. It is greater than this sum to the degree that it is a deft and skillful integration and is enhanced thereby.

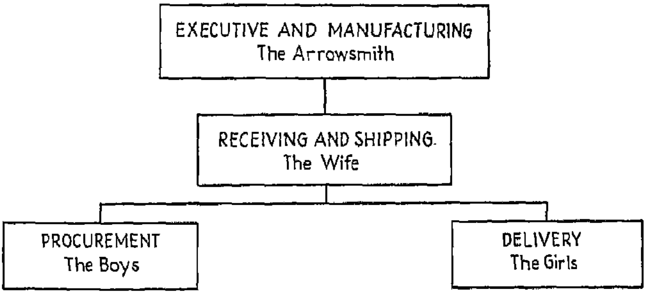
In every manufacturing enterprise there are many functions to be performed or discharged and all are interdependent upon one another so that if we wish each part or function to operate smoothly and efficiently we must so arrange them that they are correlated and that the interaction between them will be unimpeded. The making of this arrangement is called "designing the organization." It is not enough to have the finest individual departments possible but they must be so arranged, internally and externally, that each interacts with the others in such a way that all function as a unit. The music of an orchestra composed entirely of virtuosos, all playing independently of the others, is a horrible thing to hear, but, when each plays his predetermined part in unison with the others and in accordance with the instructions of the leader, the result is entirely different.

In ancient times each artisan or craftsman performed all the functions of manufacture himself. In consequence, his output was extremely limited and so it remained until he discovered the advantages to be gained through delegating responsibility. The story is told of an arrowsmith who lived many years ago in a small community in the hills of Scotland and who is said to have invented organization in industry. I cannot vouch for the truth of the story, but some such thing must have happened somewhere at some time. Since it is illustrative of the early development of organization, I shall repeat it here.

Although deft and skillful at his craft, the arrowsmith could produce only 12 arrows per day that would meet his exacting standards. This was just about enough to supply the needs of the hunters, who provided food for the community, for they could recover many of their arrows. The time came, however, when hostilities arose between his little band and that from across the valley to the north. More arrows were needed for defense against invasion. He hit upon the idea that if he could be relieved of the necessity of gathering flints for heads, straight sticks for shafts, and feathers for tails, he could spend more time making the arrows and thereby produce more each day. He therefore sent his three sons into the hills to gather the raw materials he required. At that moment organization was born. He had delegated responsibility to the boys and they, in turn, received their instructions and guidance from him. Responsibility flowed from the boys to the father and authority from the father to the boys.

The result of this delegation of responsibility was an increase in the number of arrows per day to 24. This, however, was still not enough to make the little community entirely secure and more arrows were needed. He recounted his time and found that a great deal was consumed in delivering the arrows to the bowmen located at the various strategic points of defense. Why could his daughters not help with this chore? They could and did but still more arrows were needed. He found he was spending a lot of time checking the materials brought in by the boys and counting out the arrows to be taken to each bastion by the girls who could not count. His wife had watched him make arrows for years. Why could she not help since the children would be busy and not require much care? She could and did. Each morning she instructed the boys as to the requirements of the following day, and she counted and checked their materials each night as they came in. She also counted out the arrows for the girls to deliver to the bowmen and gave them instructions.

Our arrowsmith had now increased his production to 40 arrows per day and had thereby rendered his community safe from invasion. The method, however, was the most important feature of the process. He had invented industrial organization. In terms of our modern organizations, the arrowsmith's might be diagrammed as follows:



Throughout the years since the arrowsmith, and particularly during the twentieth century, industrial organization has made great strides and without this development mass production would have been an impossibility. Although comparatively new in industry, organization is an old story to the soldier. It has undoubtedly reached its highest development in the army, and it was Julius Caesar's great genius for organization that made him an outstanding general. The greatest organization ever achieved by man is probably that of General Dwight D. Eisenhower, who united the armies, navies, and air forces of the Western Allies, landed in France, and destroyed the military might of Germany in less than one year. It was the organization of the myriad armed units of the allied nations into an integrated whole, functioning as one, that made this stupendous feat possible.

In designing a modern industrial organization, it must be remembered that it should provide for the delegation of the specific responsibilities of that particular enterprise and, consequently, should be designed for that purpose only. In short, it should be entirely functional.

Many manufacturers make the signal mistake of designing their organization to fit their personnel or to fit some particular individual. A moment's reflection will expose the fallacy of this procedure. Only the business can be permanent; people are transient. Speaking of people in industry, a prominent executive once remarked:

They come, they go,
They die, they grow,
But the *show* goes on
Forever!

An organization should be designed to carry on the business of the enterprise in the smoothest and most efficient manner, all arguments to the contrary notwithstanding. It has been repeatedly demonstrated that the most satisfactory method of procedure is to list the various functions to be performed in carrying on the business of the enterprise and then to arrange them in logical order. Although no two enterprises are identical, there is a great similarity in their various functions. Hence, the organization of any large and well-integrated enterprise may be used as a check list but should never be copied. Each of the functions will probably exist in a greater or lesser degree in the enterprise under consideration although they may have different names. Product engineering is an important function in a large mechanical enterprise, but one would scarcely expect to find the function in the organization of a brassière factory. Nevertheless, it is there, or should be, perhaps *known as "creative design" or just "design."*

Functions

The following is a list or outline of functions common to most manufacturing enterprises, together with a brief discussion of each. The functions are arranged in order and a decimal system of numbering them has been used wherein, by dropping the last digit, the number of the function of which it is a subdivision is obtained. The relationship of the functions and subfunctions is the important thing and not the numbers. The various functions discussed differ widely in practice, and an effort has been made to strike some sort of mean or average consistent with good practice:

OUTLINE AND DISCUSSION OF THE FUNCTIONS OF A TYPICAL MANUFACTURING ORGANIZATION †

1. Provide the Capital

The Stockholders

In addition to providing the capital, the Stockholders usually perform other functions. They select the Board of Directors, pass on matters of broad, long-range general policy, and receive and consider the report of the management covering the period since their last meeting.

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† Organization Diagram in Fig. 14, p. 112.

2. Determine the General Policies

The Board of Directors

The Board of Directors establishes the basic general policies, settles financial matters of major importance, and selects the Executive Committee and the officers of the company, determining their compensation. It also receives reports from the management on operation since the last meeting and passes judgment as to whether or not the results have been satisfactory. Emergency action taken by the management between meetings is generally submitted to the Board for ratification. It declares the annual dividend. It is responsible only to the Stockholders.

3. Determine the Executive Policies

The Executive Committee

In the larger companies an Executive Committee, elected by the Board of Directors, determines the ways in which the basic general policies of the company shall be carried out. It occasionally takes emergency action between meetings of the Board of Directors submitting such matters to the Board at its next meeting for ratification. It is responsible to the Board of Directors.

4. General Administration

The President

The President is the chief executive officer of the company and directs the carrying out of the policies established by the Board of Directors as well as those determined by the Executive Committee. He is usually a member of the Executive Committee and the Board of Directors and is responsible to the Board of Directors.

4.1 * LEGAL ADMINISTRATION

The Secretary

The Secretary is usually considered the legal officer of the company and often is its General Counsel. He directs the keeping of the minutes of the meetings of the Board of Directors, the capital stock records, the dissemination of corporate information, and the employment of counsel both general and special. He is responsible to General Administration.

4.2 * PROPERTY ADMINISTRATION

The Treasurer

The Treasurer is the financial officer of the company and is the custodian of all the company's property. He keeps the capital and property accounts, invests the company's surplus funds, makes all real estate transactions, insures the company's properties and interests, and makes all payments from the company's general funds. He is responsible to General Administration.

4.3 * ENGINEERING

Vice President for Engineering

The Vice President for Engineering is the chief technical officer of the company and head of the Engineering Division. He establishes the Technical and Engineering policies and directs their execution. He is responsible to General Administration.

4.31 * * RESEARCH AND DEVELOPMENT

Director of Research

The Director of Research initiates and carries out all research, development, and experimental work on the company's products, endeavoring always to keep them up to date and ahead of competition. He also carries on such experimental work on processes and methods as requested by the Process Engineer or by duly approved employee suggestions. He is responsible to Engineering.

4.32 * * DESIGN

Chief Engineer

The Chief Engineer directs all design both on products and processes. He is in charge of the general drafting room and executes such designs, layouts, etc., as requested by other department heads in the Division as well as those designs requested by the Process Engineer and the Plant Engineer. He is responsible to Engineering.

4.33 * * LABORATORIES

Chief Technologist

The Chief Technologist directs such chemical, metallurgical, and other laboratories as are maintained by the company for controlling the quality of materials, the excellence of the product, and the accuracy of processes. He is responsible to Engineering.

4.34 * * APPROPRIATIONS

Appropriations Engineer

The Appropriations Engineer reports on desirability of all projects for which a request for appropriation has been made. He estimates the cost and the benefits to be gained and upon completion of the project compares actual costs and benefits with the estimates. He is responsible to Engineering.

4.35 * * APPLICATION

Application Engineer

The Application Engineer endeavors to find new applications for and extended uses of the company's products. He carries on field tests and experimental runs striving continually to increase the scope of the products. He is responsible to Engineering.

4.4 * MARKETING

Vice President for Marketing

The Vice President for Marketing directs the Market Division and all the company's new business activities. He directs all sales, the making of contracts, advertising, public relations activities, and the technical experts of the Division. He is responsible to General Administration.

4.41 * * SALES

Sales Manager

The Sales Manager directs the company's sales forces. He is responsible to Marketing.

4.42 * * CONTRACTS

Contract Manager

The Contract Manager negotiates all the contracts for the services of the company other than sales contracts for the company's standard products. He is responsible to Marketing.

4.43 * * ADVERTISING

Advertising Manager

The Advertising Manager directs all the company's advertising. He is responsible to Marketing.

4.44 * * PUBLIC RELATIONS

Public Relations Manager

The Public Relations Manager directs all activities having a bearing on the company's good will. He arranges or clears all speaking engagements for officers and employees. He edits all papers and articles published by officers and employees where the company's name is used. He makes such other arrangements as he thinks will add to the company's standing. He is responsible to Marketing.

4.45 * * SALES TECHNICAL

Sales Engineer

The Sales Engineer directs the making of sales to technical consumers or others where technical knowledge of the product and its application is a factor. He is responsible to Marketing.

4.5 * ACCOUNTING

Comptroller

The Comptroller is the chief accounting officer of the company and directs the Accounting Division. The name derives from the French word *compter* meaning to count. He is responsible to General Administration.

4.51 * * GENERAL ACCOUNTS

Chief Accountant

The Chief Accountant directs the keeping of the general accounts of the company and is responsible to Accounting.

4.52 * * PAY ROLL ACCOUNTS

Pay Roll Accountant

The Pay Roll Accountant directs the making out of all pay rolls and deductions therefrom. He also directs the paymaster and keeps all pay roll accounts. He is responsible to Accounting.

4.53 * * COST ACCOUNTS

Chief Cost Accountant

The Chief Cost Accountant directs all cost accounting of the company and is responsible to Accounting.

4.54 * * CREDITS AND COLLECTIONS

Credit Manager

The Credit Manager directs all credit investigations and determines whether or not credit will be extended to customers and in what amount. He also directs the billing of customers and the collection of moneys due. He is responsible to Accounting.

4.55 * * GOVERNMENT REPORTS

Tax Accountant

The Tax Accountant directs the preparation of all tax returns whether Federal, state, or local and prepares and files all required government reports. He is responsible to Accounting.

4.6 * PERSONNEL

Director of Personnel

The Director of Personnel directs the Personnel Division. He determines the policies of the company in dealing with its employees and is responsible for the maintenance of cordial relations with them. He is also usually charged with the function of plant protection and is responsible to General Administration.

4.61 * * EMPLOYMENT

Employment Manager

The Employment Manager directs the procurement, hiring, and placement of all employees and is responsible to Personnel.

4.62 * * MEDICAL AND SAFETY

Medical Director

The Medical Director, usually a physician, performs or directs all medical examinations of employees or prospective employees, instructs all employees in hygiene and safety, and directs hospitalization and first aid. He is responsible to Personnel.

4.63 * * INDUSTRIAL RELATIONS

Director of Industrial Relations

The Director of Industrial Relations is responsible for the maintenance of cordial relations between the company and its employees. He negotiates union contracts, adjusts grievances of importance, and is responsible for the proper evaluation of all jobs. He executes the personnel policies of the company as determined by the head of the division and is responsible to Personnel.

4.64 * * EMPLOYEE TRAINING

Training Manager

The Training Manager directs all employee training both for new employees and in order to increase the stature and effectiveness of the older ones. He is responsible to Personnel.

4.65 * * PLANT PROTECTION

Chief of Police

The Chief of Police directs the protection of the company's property and personnel from fire, theft, riot, and other contingencies. He directs the police force and the watchmen. He is responsible to Personnel.

4.7 * OPERATIONS

Vice President for Operations

The Vice President for Operations directs the Operating Division and is sometimes called the "Executive Vice President." He determines the operating policies of the company and heads what is generally known as the "manufacturing activities of the company." He is responsible to General Administration.

4.71 * * PRODUCTION CONTROL

Production Manager

The Production Manager directs the planning and control of production, the procurement and movement of materials and other traffic, and reports regularly to management on the status of all orders and contracts. He is responsible to Operations.

4.711 * * * PRODUCTION PLANNING

Planning Manager

The Planning Manager Directs the preparation of delivery and production schedules, the machine loading controls, and the dispatching of work orders. He is responsible to Production Control.

4.712 * * * MATERIAL CONTROL

Material Control Manager

The Material Control Manager directs the keeping of stock, stores, and the records thereof, usually some form of perpetual inventory, as well as the receiving and shipping activities. He is responsible to Production Control.

4.713 * * * PROCUREMENT

Purchasing Agent

The Purchasing Agent buys all materials, supplies, purchased finished parts, and facilities as well as arranges for all subcontract work. He is responsible to Production Control.

4.714 * * * TRAFFIC

Traffic Manager

The Traffic Manager directs all transportation of materials, supplies, etc., outside the confines of the plant and arranges for automobile and railroad transportation for company employees traveling on company business. He is responsible to Production Control.

4.715 * * * REPORTS

Report Clerk

The Report Clerk prepares all reports on production required by management for purposes of over-all control. He is responsible to Production Control.

4.72 * * INSPECTION

Chief Inspector

The Chief Inspector directs the work of all the inspectors except that which is done in the laboratories under the direction of the Chief Technologist. He is responsible to Operations.

4.721 * * * OUTSIDE INSPECTION

Outside Inspector

The Outside Inspector directs or performs all inspections of materials, parts, etc., made off the company's premises. He is responsible to Inspection.

4.722 * * * RECEIVING INSPECTION

Receiving Inspector

The Receiving Inspector directs the inspection of all materials, parts, tools, facilities, etc., before certification for payment. He is responsible to Inspection.

4.723 * * * IN PROCESS INSPECTION

Parts Inspector

The Parts Inspector directs the inspection of all materials, parts, and subassemblies during processing or manufacture. He is responsible to Inspection.

4.724 * * * FINAL INSPECTION

Final Inspector

The Final Inspector inspects the finished product, before packing for shipment, making such performance tests thereon as are specified. He is responsible to Inspection.

4.725 * * * INSPECTION REPORTS

Inspection Clerk

The Inspection Clerk compiles all inspection records, calculates ratios and percentages, and prepares such reports as required by the management. He is responsible to Inspection.

4.73 * * PROCESS ENGINEERING

Process Engineer

The Process Engineer directs the determination of the methods, tooling, processes, and standards for all operations. He evaluates performance and is responsible to Operations.

4.731 * * * LAYOUT

Layout Engineer

The Layout Engineer determines the most economical and efficient layout for tools and processes and keeps it continually abreast of changes and practice. He is responsible to Process Engineering.

4.732 * * * METHODS AND ROUTING

Methods Engineer

The Methods Engineer determines the most economical and efficient methods to be employed, the best speeds and feeds for the various machines, and the correct routing of material and parts. He prepares the operation sheets and is responsible to Process Engineering.

4.733 * * * STANDARDS AND PERFORMANCE

Performance Engineer

The Performance Engineer determines and

keeps up to date, by time studies or other means, proper standards for employee and machine performance. He compares actual performance with the standards, and, in collaboration with the Personnel Division, he sets piece and incentive rates of pay. He is responsible to Process Engineering.

4.734 * * * TOOL DESIGN

Tool Engineer

The Tool Engineer directs the design of all tools, jigs, and fixtures and inspects them before placing in service. He is responsible to Process Engineering.

4.735 * * * TOOL ROOM AND CRIBS

Tool Foreman

The Tool Foreman directs the making of all tools, jigs, fixtures, the operation of the tool cribs, and all tool grinding. He is responsible to Process Engineering.

4.74 * * PLANT ENGINEERING

Plant Engineer

The Plant Engineer is a department head and is sometimes referred to, outside of the automobile industry, as the Master Mechanic. He directs all maintenance, construction, and repair work as well as the utilities and services in the plant. He is responsible to Operations.

4.741 * * * POWER PLANT

Power Engineer

The Power Engineer operates the power plant. He is responsible to Plant Engineering.

4.742 * * * CONSTRUCTION AND ALTERATION

Construction Foreman

The Construction Foreman directs all construction, alteration, and repair work on the buildings and installs new facilities or moves existing ones where directed by the Layout Engineer. He is responsible to Plant Engineering.

4.743 * * * MAINTENANCE

Maintenance Foreman

The Maintenance Foreman directs all maintenance work, both preventive and repair, on the machinery and other manufacturing facilities. He is responsible for the proper lubrication of all machinery and is responsible to Plant Engineering.

4.744 * * * INTERNAL TRANSPORTATION

Transportation Foreman

The Transportation Foreman directs the movement of all materials, parts, supplies, and facilities within the confines of the plant except those which are carried on conveying equipment. Under his jurisdiction are the lift trucks, tier trucks, auto trucks, and medium and heavy cranes. He is responsible to Plant Engineering.

4.745 * * * SWEEPING AND CLEANING

Janitor

The Janitor directs the cleaning and sweeping forces and is responsible for the general housekeeping throughout the plant and offices. He is responsible to Plant Engineering.

4.75 * * MANUFACTURING

Plant Superintendent

The Plant Superintendent directs all actual manufacturing activities and is the top man in the plant. He is responsible to Operations.

4.751 * * * FOUNDRY SECTION

Foundry Superintendent

The Foundry Superintendent directs all operations in the Foundry Section and is responsible to Manufacturing.

4.7511 * * * * PATTERN SHOP

Master Pattern Maker

4.7512 * * * * MOULDING AND CORES SHOP

Foreman

4.7513 * * * * MELTING AND POURING SHOP

Foreman

4.7514 * * * * CHIPPING AND CLEANING SHOP

Foreman

4.7515 * * * * SAND CONDITIONING

Foreman

4.752 * * * MACHINE SECTION

Machine Superintendent

The Machine Superintendent directs all operations in the Machine Section and is responsible to Manufacturing.

4.7521 * * * * TURNING SHOP

Foreman

4.7522 * * * * BORING AND PLANING SHOP

Foreman

4.7523 * * * * MILLING AND BROACHING SHOP
Foreman

4.7524 * * * * DRILLING SHOP
Foreman

4.7525 * * * * GRINDING SHOP
Foreman

4.753 * * * ELECTRICAL SECTION
Electrical Superintendent

The Electrical Superintendent directs all operations in the Electrical Section and is responsible to Manufacturing.

4.7531 * * * * MOTOR SHOP
Foreman

4.7532 * * * * CONTROLS SHOP
Foreman

4.7533 * * * * INSTRUMENT SHOP
Foreman

4.7534 * * * * SUBASSEMBLY SHOP
Foreman

4.7535 * * * * WIRING SHOP
Foreman

4.754 * * * SHEET METAL SECTION
Sheet Metal Superintendent

The Sheet Metal Superintendent directs all operations in the Sheet Metal Section and is responsible to Manufacturing.

4.7541 * * * * SHEAR SHOP
Foreman

4.7542 * * * * SLITTING SHOP
Foreman

4.7543 * * * * STAMPING SHOP
Foreman

4.7544 * * * * FORMING SHOP
Foreman

4.7545 * * * * FASTENING SHOP
Foreman

4.755 * * * ASSEMBLY SECTION
Assembly Superintendent

The Assembly Superintendent directs all operations in the Assembly Section and is responsible to Manufacturing.

4.7551 * * * * ASSEMBLING SHOP
Foreman

4.7552 * * * * ERECTING SHOP
Foreman

4.7553 * * * * PAINT SHOP
Foreman

4.7554 * * * * TESTING SHOP
Foreman

4.7555 * * * * PACKING SHOP
Foreman

The Organization Chart

Once the list of functions has been made as completely as possible the arrangement should be started. Let us begin with General Administration and perform our arrangement graphically. When we are finished we shall have what is known as an "organization chart." The process is not unlike the diagramming or parsing of a sentence in grammar. Let us take a large sheet of paper and write General Administration in the center, near the top, and draw a box around it. Next, on a line an inch or so below, let us write the various functions into which General Administration is divided or, as they usually are called, "the functions reporting to General Administration." If our list has been completely made, we will find them to number about seven. There should never be more than seven. They are as follows: Legal Administration, Property Administration, Engineering, Marketing, Accounting, Personnel, and Operations. All are generally considered staff functions except Operations, which is a line function. There is generally a slight distinction made between the first two functions and the others. The first two are said to be administrative functions, whereas the others are said to be executive functions, and they are usually discharged by the Secretary and Treasurer respectively. The next step is to subdivide these executive functions into those which report to each of them. After this has been done, further subdivision should be made until the desired degree or amount of detail has been attained. Figures 14 and 15 show two such charts. The first is designed for a manufacturing enterprise making a product composed of machined castings, small parts, electrical components, and sheet-metal. The entire product is made in one plant that employs in the neighborhood of 3,000 men. The second is for an enterprise having several plants. All charts, diagrams, and arrangements should be made and studied by functions only, and the names or titles of those discharging them should not be considered until the functional arrangement is complete. So doing will materially assist in maintaining the complete objectivity so necessary to fit the organization to the business of the enterprise.

Another form of organization chart that is becoming increasingly popular is illustrated in Figs. 16 to 18. In this form only one breakdown is made on each sheet. The first sheet usually shows the breakdown of General Administration into divisions. The next sheets each show the breakdown of a division into departments. Then comes a number of sheets each showing the breakdown of each department into sections, and so on into shops, groups, etc. Figures 16, 17, and 18 show the same organization depicted in Fig. 14 and in the above list of functions.

Nomenclature

Manufacturing nomenclature is usually extremely vague, since there has never been, to my knowledge, any concerted attempt to standardize it. In fact, it even seems as if many companies go to great lengths to coin new and bizarre titles for their executives and very ordinary functions. Only today I heard a new one.

Case XXII—*The Case of the Titled Executive*

> A young man, whom I know, told me he had just been engaged as Executive Assistant President by a large company. Although no one can say for sure, probably least of all the President himself, it looks as if a stab was made at combining the jobs of Executive Vice-president and Assistant to the President in one glorious sunburst, and they made up a title to fit.

It brings to mind either the animal known as a "Tiglon," which is a cross between a tiger and a lion, or the two Negroes from Georgia, one of whom had been at the glue works looking for a job. His friend asked him on his return, "Well, Sambo, wuz you employmentated or wuz you discomboobberated?"

Subdivisions

A good fight can usually be had over the names of the various subdivisions of a company. If the subdivisions are

NOTE: Line functions roman.
Staff functions italic.

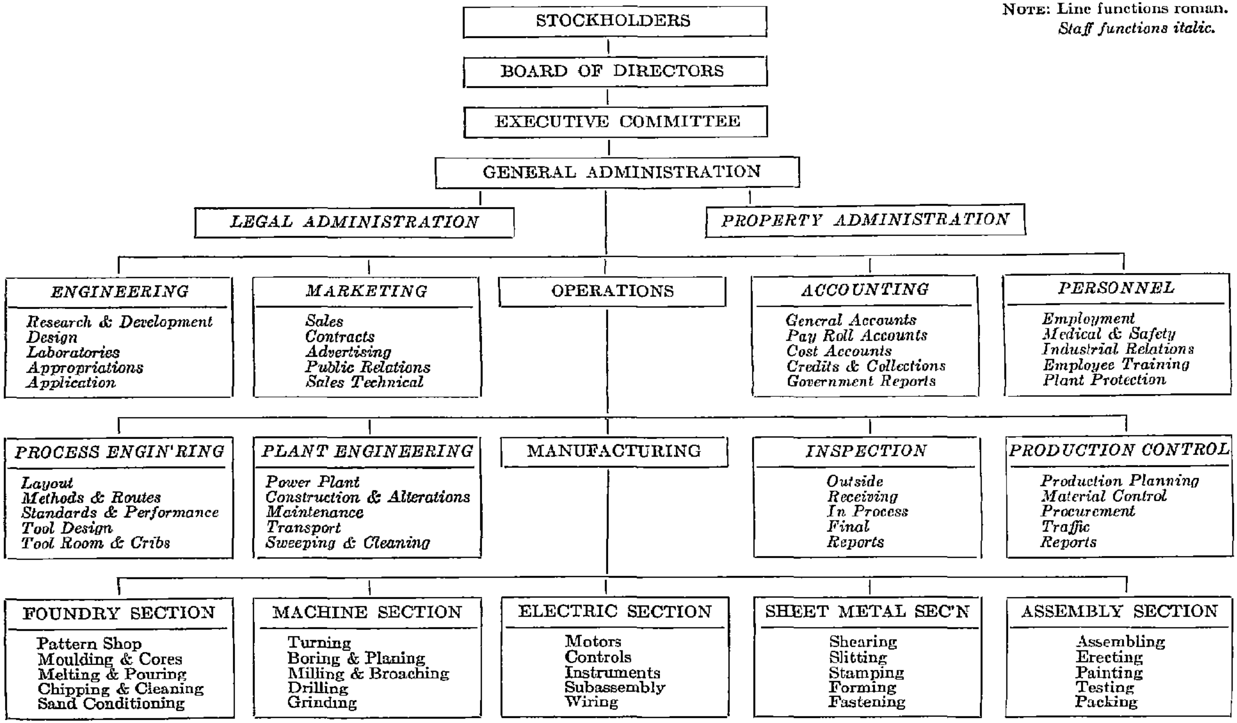

FIG. 14.—Line and staff functions ordinarily reporting to the president of a manufacturing enterprise having about 3,000 men.

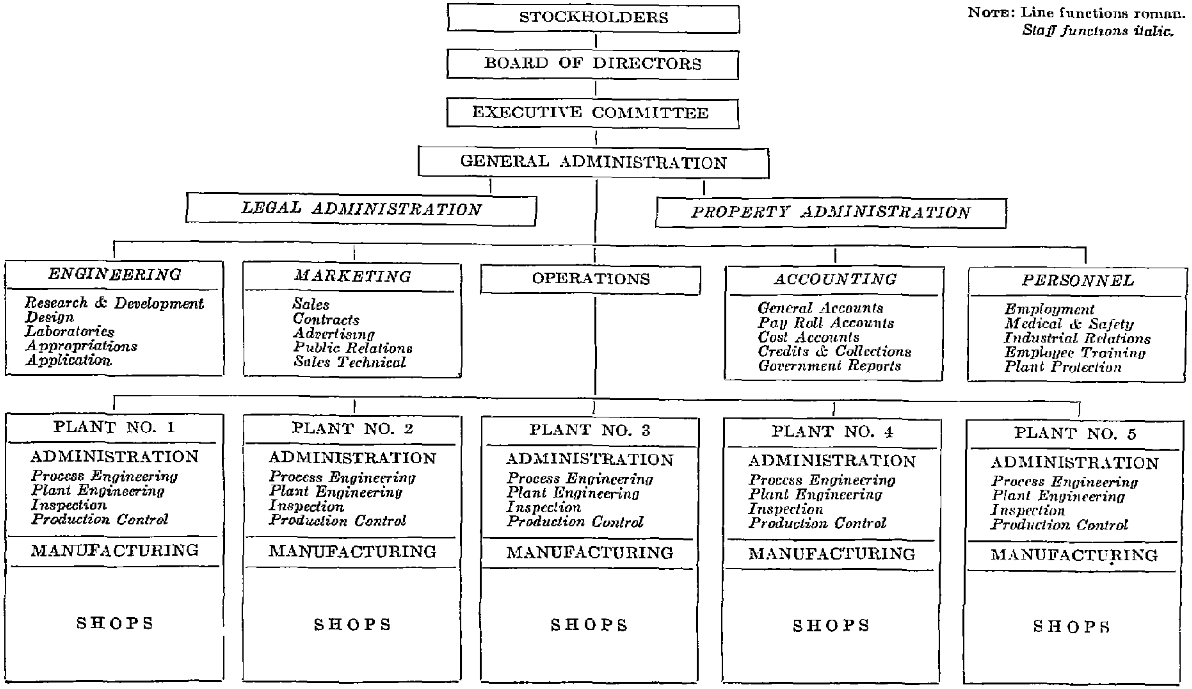

FIG. 15.—Line and staff functions ordinarily reporting to the president of a manufacturing enterprise having several plants.

NOTE: Line functions roman.
Staff functions italic.

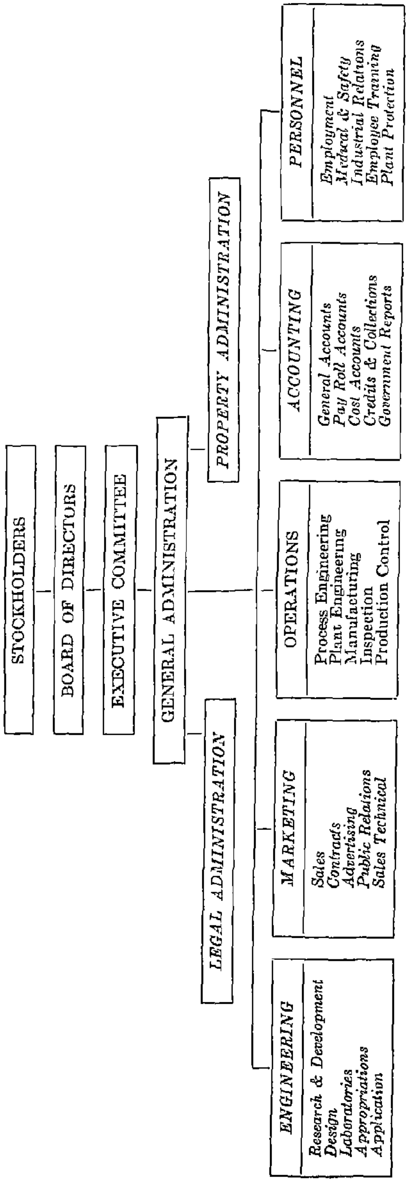

FIG. 16.

Note: Line functions roman.
Staff functions italic.

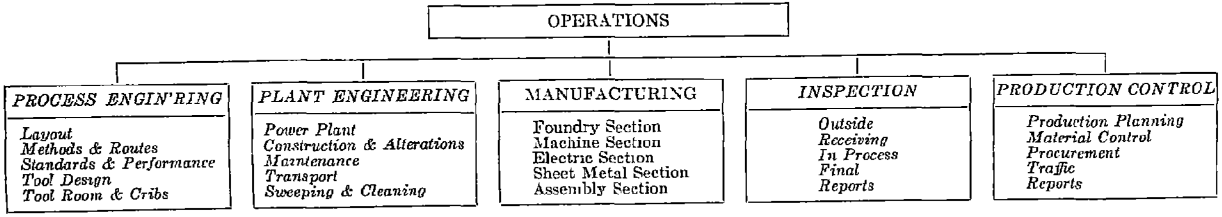

Fig. 17.

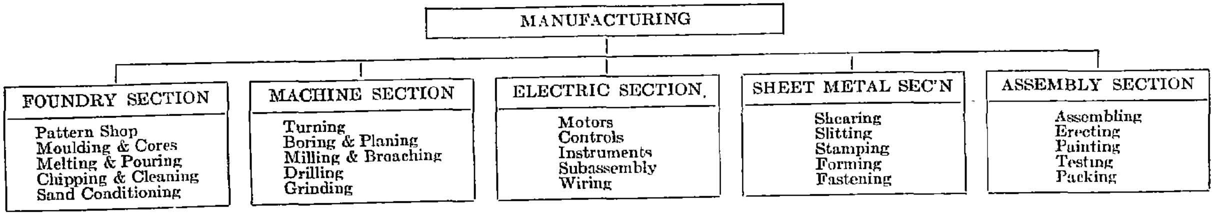

Fig. 18.

to be functional rather than geographic or productwise, I personally favor making the largest a division, then subdividing the divisions into departments, the departments into sections, and the sections into shops or groups. The Army subdivides as follows: Army, corps, division, brigade, regiment, battalion, company, platoon, and squad. The Consolidated Edison Company of New York, one of the best organized companies I have ever seen, divides as follows: department, bureau, division, group.

Another controversial term is "Production." Of late years Production is usually used to designate the function of Production Control. Etymologically this is wrong, since the word "production" means "the act of producing," and the production control function actually produces nothing.

Case XXIII—*The Case of the Ambiguous Production*

A colleague of mine was driven, through sheer desperation, to apply the term "conversion" to the manufacturing function of one of his client companies since they had called both functions "production" and were always doubtful as to which was meant. He justified it by saying it was this function that converted the raw materials into the finished product.

This, of course, is precisely the meaning of "manufacturing." Throughout this book I have preferred to use the latter word. I have used the word "operations" to include also the staff functions incident to manufacturing. I do not maintain that this is even good terminology but, to me at least, it seems to have more meaning than the other terms used so frequently.

IN DESIGNING YOUR ORGANIZATION

DO	DON'T
1. Subdivide by function only	1. *Don't* subdivide capriciously or illogically
2. Break up one function at a time	2. *Don't* consider the chart to be the organization
3. Limit the number of subdivisions to about seven	3. *Don't* overload your executives and supervisors
4. Fit your personnel into your organization	4. *Don't* fit your organization around your personnel

CHAPTER IX

FORMALIZING THE ORGANIZATION

Many are the meanings of unwritten law.

FORMALIZING THE ORGANIZATION

WHEN the form of organization has been decided upon and the charts have been prepared, the next step is to write the organization manual. This is an extremely important phase since it is the formalizing of the organization. I referred, in the previous chapter, to the vagueness of industrial terminology, and it is this very thing that makes it unsafe to depend on a few uncertain words, such as those used to describe a function or the title of a job, to convey any idea of what the job or function entails.

The Organization Manual

The organization manual describes, in writing, the duties and responsibilities incident to each function in the organization. This eliminates overlapping responsibilities and the very prevalent error, in many plants, of having people with a multiplicity of bosses. Although many of our modern executives are extremely religious, they probably never have read that verse from the Bible that says, "No man can serve two masters."

There are a number of ways of going about the preparation of an organization manual, but however it is done, there are certain things that are common to all. Each function should be separately described and the following information should be given with respect to it:

1. The name of the function, such as "Research and Development" or "Layout"
2. The title of the person designated to direct or administer the function, such as "Process Engineer," "Sales Manager," or "Purchasing Agent"
3. The nature of the function, that is, whether it is an Administrative, Executive, or Supervisory function; whether it is a Staff or Line function
4. Its location in the organization—what Division, Department, Section, Shop, or Group the function is in.
5. The Limits of Authority
6. The function and title of incumbent to whom the function is responsible
7. A list of the functions that are responsible to it
8. A list of the responsibilities
9. The general duties
10. Duties and responsibilities with respect to purchase requisitions †
11. Duties and responsibilities with respect to conferences
12. What committees the incumbent shall be a member of
13. Duties and responsibilities with respect to the handling of grievances
14. Duties and responsibilities with respect to liaison with other functions in the organization
15. Responsibilities in connection with public relations
16. Responsibilities in connection with industrial relations
17. Instruction relative to the preparation of routine and special reports
18. A list of specific duties
19. Any pertinent special instructions
20. Miscellaneous

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† I have never yet seen a company where more than a few people were familiar with the procedures for handling purchase requisitions.

Job Description Form

In the organization chart studied in the previous chapter there are 86 functions described, and in some organizations that I have studied there have been many times this number. Needless to say, it is a rather intricate task to record so much data on so many jobs, and a convenient method for so doing that will eliminate a lot of repetitive writing is to have a form, either mimeographed or printed, where there are blanks left to fill in or words to be crossed out. Figure 19 shows a form I have used for this purpose filled out for the job of Process Engineer. Using such a form has the advantage of giving the job descriptions a desirable uniformity that would otherwise be difficult to obtain and it also helps avoid inadvertent omissions.

JOB SPECIFICATION FORM

NAME OF FUNCTION Process Engineering *TITLE* Process Engineer

NATURE OF FUNCTION Staff *DIVISION* Operations

DEPARTMENT Process Eng'g. *SECTION* — *SHOP* —

AUTHORITY He shall be designated as a Department Head and shall have authority to fill jobs and make promotions in the Dept. He may approve expenditures for new facilities up to $500 and for maintenance or supplies up to $1000

REPORTS TO V.P. for Operations

DIRECTS Layout Eng'r., Methods Engr., Performance Eng'r., Tool Eng'r., Tool Foreman,

RESPONSIBLE FOR Layout, Methods, Routing, Time Standards, Performance, Tool design, Tool Making, Tool Grinding, Tool Cribs.

GENERAL DUTIES He shall administer the affairs of the .. Dept. .... in the most efficient and economical manner, reporting monthly . in writing to the V. P. for Op. on the state of the . Dept. . ... . and the progress of the work in hand.

PURCHASE REQUISITIONS He shall *issue, approve, or review, prepare, originate, and follow up* all purchase requisitions *originating in, required by* the . Dept. ... . for all *equipment, materials, tools,* or *supplies* to be used in the .. Dept. ....

....

CONFERENCES He shall attend all conferences of Dept. heads. . as directed by the V. P. for Op. , reporting to him on the proceedings thereof as soon as possible. He shall call and preside over such conferences within the . Dept. .. as he deems necessary or advisable.

COMMITTEES He shall be a member of the following committees and chairman of those marked with an * :

Operating.................
..Equipment selection*...

....

GRIEVANCES He shall act as final arbiter in all disputes or grievances arising within the .. Dept. ...., referring those he is unable to settle to .. Industrial .. Relations ..

....

LIAISON He shall maintain liaison with other related .. Depts. ... or activities to whom he shall supply such data and information as they may require in the conduct of their work, obtaining from them such as he may require in his, all through the established channels.

PUBLIC RELATIONS

He shall at all times be responsible for the conduct of the personnel of the . Dept. . . . . . . in the maintenance of good will and sound public relations. He will receive special instructions in this regard from General Administration.

INDUSTRIAL RELATIONS

He shall at all times be responsible for the maintenance of sound industrial relations with the personnel of the Dept. . and will, from time to time, receive special instructions in this regard from *~~General Administration, Personnel, and~~ Industrial Relations.*

REPORTS

He shall *~~make~~, direct the making of*, the following *general reports, ~~special reports~~, ~~lists~~,* or *schedules*, transmitting them to the . V.P. for Op. . on the . 1st . . . . . . *day* of each *~~week~~, month, ~~quarter~~, ~~year~~:*

. . Performance . . report . . . . .

. Schedule . of . . facilities . . .

. . . .

SPECIFIC DUTIES

The specific duties of this function follow together with special instructions and miscellaneous comment:

. . . .

. . . .

. (Specific . duties . will . depend . on . the . .

. . individual . plant . involved.) . . . .

. . . .

. . . .

. . . .

FIG. 19. Suggested form for preparing organization manual.

Format

Preceding the job descriptions, it is a good idea to include a brief history and description of the company, of its policies, and of its products so that the over-all objectives of the enterprise are ever kept in mind. Immediately following this and before the job descriptions should come the organization charts.

It is impossible for any man or group of men to prepare an organization manual that will be perfect at the start. Only trial and error can produce a really good one and, consequently, there will be many changes at first due to original mistakes. These will soon be eliminated, and then only the normal alterations due to changing conditions will have to be made. The manual should be issued in loose-leaf form to facilitate changes. It is a good thing to delegate specifically the responsibility for keeping the manual correct and up to date to one individual who then can, with guidance from the management, keep it abreast of all changes and a valuable and living document rather than a lot of waste paper.

Distribution

The wider the distribution of the manual among the employees, the better. I recommend that every supervisory employee be given a copy and that numerous copies be kept conveniently available for consultation by the workers if they so desire. This creates a feeling of confidence in the company, which is what a magician attempts to do when he rolls up his sleeves. The effect of the manual upon the executive and supervisory personnel is similar. It also eliminates a lot of company politics. The absence of any written description of their jobs creates a tendency on the part of some employees to try to increase their stature by gathering unto themselves responsibilities they should not have. It also encourages the

"Gold Brick" who would shirk his responsibilities by passing the buck.

One should certainly guard against the frightful error made by a client of one of my colleagues.

Case XXIV—*The Case of the Hidden Manual*

> A very comprehensive manual was prepared for him, and he was asked how many copies he wanted struck off. He said, "You had better send us three. One is for the Chairman of the Board, another for the President, and I think we had better have another to keep in the safe."

This is reminiscent of the jealous architect who tore up all his plans as soon as he finished them so no one could steal his ideas.

IN FORMALIZING YOUR ORGANIZATION

DO	DON'T
1. Orient each job 2. Be specific 3. Be thorough	1. *Don't* be vague 2. *Don't* give anyone two bosses 3. *Don't* keep the manual a secret

CHAPTER X

EVALUATING THE ORGANIZATION

Render unto Caesar those things which are Caesar's . . .

EVALUATING THE ORGANIZATION

THE evaluation of the organization is the determination of the yearly, monthly, weekly, or hourly compensation to be paid for the performance of each function. It is quite necessary that this be done according to some definite plan or there will always be grievances, expressed or repressed, that will greatly detract from the efficient operation of the enterprise.

Secrecy

Most manufacturers realize this and endeavor to prevent the grievances by surrounding the pay rolls with great secrecy. Perhaps I should say trying to surround them with secrecy. Let me say here that no secrecy exists anywhere in the matter of pay rolls and any manufacturer who thinks it does is like an ostrich with his head in the sand and his rear end in the breeze. I have worked for a good many companies and have had many more as clients and never have I been in any organization for more than 30 days without knowing what at least 75 per cent of the executive personnel took home. I don't think that I have been unusually curious about it either. If I had really wanted to make an effort to find out, I could have had the information in a week.

Case XXV—The Case of the Secret Pay Roll

> The President of a company, for whom I worked, once boasted about how well he had kept his pay roll secret. He said that no one, not even his wife, knew how much he drew, for he made out the top executive pay roll himself from a special account and deposited his checks by mail in two out-of-town banks. I told him that I knew how much he drew and had known it ever since I came. He was incredulous until I told him how much it was and then spent the better part of the next month trying to find out how I knew. He never found out, for it came to me through a friend who was a bank auditor and who had picked up the information more or less accidentally.

Such information never comes through orthodox channels but always in a roundabout way that one would never suspect. The trouble is that these roundabout ways are legion and, like murder, it always comes out.

Realizing that it is impossible to keep pay roll inequities a secret, why is it not the most sensible thing to do to eliminate them once and for all? If the enterprise is a new one, this is very easy to do. In an established enterprise with an unfair system of compensation, it is not so easy but nevertheless possible. Due to pressure from the unions and the government, many companies have undertaken job evaluation among their nonsupervisory personnel, but few have made a clean sweep of it from cellar to garret. Those who have still try to keep it a secret for reasons best known to themselves.

I suppose it is too much to expect the elimination of secrecy in less than two or three generations, but I think it is axiomatic that the less of it there is in a company the less resentment and petty politics will be found and the smoother the operation will be. For the purposes of illustration, let us assume that secrecy has been eliminated, and let us see how to evaluate an organization. I will describe one simple method although there are many good ones to be found.

Logarithmic Evaluation

This method is known as the "logarithmic scale method" and is one of the simplest and easiest to apply. The first step is to arrange all the jobs or levels of compensation in the company in order of importance, starting with the President and ending with apprentices. Then establish the highest and lowest rates of pay.

Now for the mathematics! If you are so inclined, dear reader, you may skip this part. I am putting it in because I am told that it just isn't cricket to write a book on a technical subject without mathematics in it at all.

Since this is a description of a logarithmic method, I had best say a word or two about logarithms. My mathematics professor once told us that while spending his summer vacation in a Colorado mining camp a blasphemous miner called another a logarithm and before the fight subsided three miners and an innocent bystander were killed.

Analytical Method

For those of you who are mathematically minded, the procedure is as follows: Subtract the logarithm of the lowest pay from the logarithm of the highest pay and divide the result by the number of levels. This will be the logarithm of the number by which you will multiply the pay at any level to obtain the pay at the next highest level. For example, if the highest pay in the company is \$25,000 per year, the lowest is \$1,500, and there are 15 levels, it works like this:

$$\begin{array}{lr} \log\ 25{,}000 = & 4.398 \\ \log\ 1{,}500 = & \underline{3.176} \\ \text{Difference} \quad = & 1.222 \end{array}$$

$$\text{Difference divided by } 15 = 0.081$$

0.081 is the logarithm of 1.206 approximately. Now this simply means that there is a 20.6 per cent increase from one level to the next.

Let us make a table of these amounts as applied to an organization. We shall write on the left side the list of the 15 levels of pay and on the right above the top, between each two, and below the bottom, the corresponding figures; starting at the bottom, each succeeding one is 20.6 per cent greater than the last.

There is an easier way of doing this with a piece of semilog paper that is shown in Fig. 20. This is the graphic method for accomplishing the same result and will be described later. Either method evaluates each job in a "range" as Journeyman $2,631 to $3,173 per year, a spread or range of $542.

When a person is first elevated or hired, the pay should be at the lower level. This leaves the range for increases due to merit or longevity, and when promoted to the next higher rank or level, the lower pay of that level should apply. The higher the level the greater the range as is also the difficulty of promotion.

Some orderly form of pay distribution is essential, and the spread between the officers, and in fact between all levels, should not be too great.

Case XXVI—The Case of the Poor Engineer

> There is one company I know of that has 11 plants and 29,000 employees. The President's salary was $150,000, the Executive Vice-president's was $45,000, and the Chief Engineer's was $10,000.

This may seem like a ridiculous example, but I assure you it is typical.

TABLE OF PAY RANGES

No.	Level	Pay	Range
		$24,957†	
1	President		$4,262
		20,694	
2	Division Head		3,435
		17,159	
3	Assistant Division Head		2,931
		14,228	
4	Department Head		2,430
		11,798	
5	Assistant Department Head		2,015
		9,783	
6	Section Head		1,671
		8,112	
7	Assistant Section Head		1,383
		6,729	
8	Foreman		1,149
		5,580	
9	Assistant Foreman		953
		4,627	
10	Supervisor		790
		3,837	
11	Leading Man		654
		3,173	
12	Journeyman		542
		2,631	
13	Operator		449
		2,182	
14	Laborer		373
		1,809	
15	Apprentice		309
		1,500	

† Failure to come up to the full $25,000 is due to the dropping of decimals in calculation.

Case XXVII—*The Case of the Affluent President*

> In another company having only one plant and about 600 employees, the President's salary is $200,000 and the Executive Vice President's is $24,000.

The other executives and employees, who will find this out in about nothing flat, cannot be expected to understand for there is no justification for anything even remotely approaching this ridiculous state of affairs. Everyone will be disgruntled and will look either for some other connection or some other way of increasing their own revenue until it is commensurate with the so-called "brass hats." Graft and dishonesty are openly invited by such situations. The fact that the President may be the owner of a large amount of the capital stock is no excuse for an exorbitant salary. He should get his return on his holdings in the form of dividends.

The reverse is sometimes the case although not as often.

Case XXVIII—*The Case of the Modest Executive*

> The President of one large company with which I had some dealings drew a very small salary. So small, in fact, that when the company wanted to engage a Director of Sales it was impossible to find a competent man to work for any less, or for that matter, for the same salary as the President. The Board of Directors finally prevailed upon him to accept more so that an able man could be employed. The President was a rich man and didn't need the extra money and was loath to pay the taxes on it.

Graphic Method

The simpler method spoken of above for evaluating the jobs is to take a piece of semilog paper (see Fig. 20) and divide it with straight lines into as many spaces as there are job levels. Write the name and number of the job

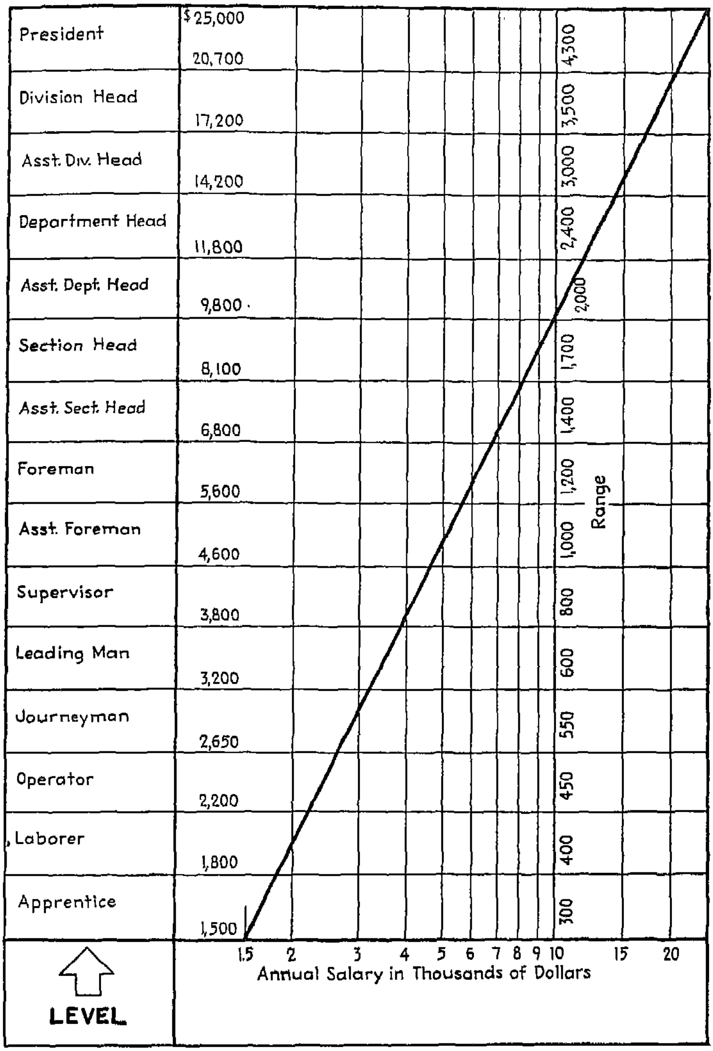

FIG. 20.—Salary evaluation.

levels between each pair of dividing lines. Now mark a point on farthest line in the low direction corresponding to the lowest rate of pay and another point on the farthest line in the high direction corresponding to the highest rate of pay. Connect these two points with a straight line, and the points where it crosses the dividing lines will give the corresponding rates of pay. The range will be the difference between the rate at the upper and lower edges of a space corresponding to a level or rate of pay.

If further subdivision is required, each space may be subdivided without changing the position of the dividing line. This, however, also decreases the range in the subdivisions, but the range over the whole space will remain the same.

The evaluation of the organization is comparatively easy in a new enterprise but, as previously stated, it is much more difficult in one that is already operating. The chief difficulty is due to the fact that some jobs will be found for which the rate of pay is more than that indicated by the evaluation. The employees receiving this overpay cannot be summarily reduced to the scale amounts. To do that would precipitate a storm and would undoubtedly cause great personal hardship. The course that is usually followed is to bring all the substandard employees up to the scale rates and to leave those who are above alone until such time as they can be promoted to a level where the range includes their present rate. Where this is impractical, one must wait until the job is vacated for some reason or other and then adjust the rate before installing the new incumbent. This merely slows down the process, but with a little patience the evaluation can be effected in an amazingly short time.

Whatever system or method is adopted, it should be rigidly adhered to, for most workable systems are rather nicely balanced and too much fudging about will vitiate the whole thing. Some executives have an idea that their organizations are unique and that nothing which is of any use to anyone else could possibly fit them without going through the process of a bill in Congress and being amended to death.

Case XXIX—*The Case of the Special Case*

This attitude is reminiscent of the experience of a friend of mine who invented the lie detector. He carried on a prodigious number of clinical experiments with criminals, both natural and artificial, from all walks of life and in many localities. He told me he has never found anyone who would not agree that the machine would work on most people, but everyone felt that he was an exception. The truth was that the only exceptions were drunks, morons, and people suffering from alopecia totalis. As a matter of fact, I didn't think it would work on me until he caught me red handed.

IN EVALUATING YOUR ORGANIZATION

DO	DON'T
1. Eliminate inequities 2. Adopt a definite plan 3. Stick to it	1. *Don't* try to hide inequities 2. *Don't* tamper with the plan 3. *Don't* keep it a secret

CHAPTER XI

STAFFING THE ORGANIZATION

A chain is no stronger
than its weakest link.

STAFFING THE ORGANIZATION

WHEN the organization has been diagrammed, manualized, and evaluated, the selection of the personnel becomes a much simpler task than if it is attempted previously. There are two principal reasons for this. First, you know what you want and how much you can pay for it, and, second, the prospective employee knows what will be expected of him and what he can expect in the way of pay.

Good men are attracted to an orderly enterprise much more than to a nondescript conglomeration where their duties are uncertain and they will have to depend on their wits to keep others in the outfit from taking advantage of them. It is much easier for the drone with a flair for politics to attach himself parasitically to the back of a good man and ride, rather than carry his share of the load, in a loosely knit organization than in a properly constituted one. The drone instinctively realizes this and consequently is not attracted to a well-constituted organization to the degree that a good man is.

Specifications

The first step should be to prepare a specification for each position to be filled. It is a good practice to select the top personnel first, as for instance the company officers and division heads, and let them select those who will be responsible to them and so on down the line to section heads. The counsel of the Director of Personnel should be sought and heeded throughout, and he should be in sole charge of the selection of all personnel below section heads. He will, of course, consult with the supervisors and executives in making his selections.

The specification should contain a description of the job that may be taken from the organization manual, the starting salary, and the range, together with such provisions as have been made for merit increases or longevity pay for the information of the prospective employee, and also such personal specifications as are deemed necessary or desirable. It should contain the age range for applicants and such educational and experience qualifications as are thought advisable after careful consideration.

None of these, however, should be looked upon as rigid, and applicants should not be fitted into them as you would a machined part into a go, no-go gauge. All the preconceived notions should be weighed as to their application to each specific candidate before using them as instruments for rejection or acceptance.

Case XXX—*The Case of the Lady's Mistake*

> A case in point is that of a medium-sized company that was recently in the market for a manager for one of their smaller plants. They wrote a job specification and turned the matter over to the personnel department at the home office. A mature and intelligent lady was assigned to "comb" the applicants who responded to newspaper advertisements. One of the items in the specification was that the applicant should have had some packaging experience, but very little was said about executive ability and leadership. Why packaging experience was a "must" in the plant manager is not entirely clear to me, but there it was in the specification, and the good lady was without authority to make exceptions.

> A man whom I have known for 25 years, and whom I should be glad to recommend to anyone as extremely capable as a plant executive and a superb leader, applied for the position and was eliminated because of his lack of previous packaging experience. I am sure they made a great mistake because, even if they got the inventor of packaging machinery, they could not have obtained a better plant executive for anywhere near what they were willing to pay.

There is a very common error made by most people in procuring executive employees. They are usually inclined to place too much stress on a knowledge of the details of the various processes and not enough on executive ability and the qualities of leadership. They will say, "Is the applicant an 'old steel man'?", or "is he a 'thorough shipbuilder'?", and not "is he a good executive?"

Details

In many cases too detailed a knowledge of the processes or minutiae of the business is a handicap rather than an advantage. The man who knows all the details backwards and forwards is often more ready to accept excuses for nonperformance than if he were less conversant with the difficulties involved. The man who comes from another industry can, and usually does, bring new ideas and methods with him.

Enthrocentrism

In old-established industries and companies there is a great tendency toward enthrocentrism. This is an "in group" feeling that manifests itself in resentment toward outsiders and particularly those outsiders who have new ideas. I have often heard the remark, "We've done it this way for 40 years . . ." or "My father and my grandfather did it this way. . . ." In view of the technological advances made in the last generation, if either of these statements is true, it strikes me as being prima-facie evidence that, whatever the method, it is antiquated and due for a change.

Candidates

There are numerous ways of obtaining applicants or candidates for positions to supplement the personal acquaintance of whoever is doing the hiring. There are regular employment agencies handling all types and levels. One can advertise in the newspapers, technical and trade journals, and contact the national or local technical societies. Many management consultants maintain an executive procurement service for their clients where the client pays the cost and the employee pays nothing. There are also personnel consultants who are in no sense employment agencies, but who assist manufacturers in recruiting their higher salaried executives. Many of the better executives hesitate to answer advertisements or to contact employment agencies but may be reached through the consultants who operate on a professional plane.

IN STAFFING YOUR ORGANIZATION

DO	DON'T
1. Be specific about each job 2. Give the candidate as much information as you require from him 3. Consider the candidate's qualifications intelligently 4. Require leadership not workmanship from your executives and supervisors	1. *Don't* apply your specifications like a snap gauge 2. *Don't* require detailed knowledge or experience where it is not necessary 3. *Don't* ask candidates for executive positions to fill out forms designed for workmen. This is a common practice and is always deeply resented

CHAPTER XII

PERSONNEL PRACTICES

As ye sow, so shall ye reap.

PERSONNEL PRACTICES

THIS chapter was supposed to deal with all the various machinations of the Director of Personnel, but I am going to take a detour. I am not a personnel man and, as Will Rogers used to say, "All I know about it is what I read in the papers"; and there has been enough in them these last few years to supply information for a lot of books, to say nothing of one little chapter in a book supposed to be dealing with fundamentals.

Therefore, I shall now ask forgiveness of my good friend and colleague, Ken Neal, for abandoning the comprehensive and complete outline he prepared for my use. Ken is a grand fellow and knows more about scientific personnel selection than anyone I know. He can do something that has always smacked to me of witchcraft and that is interpret aptitude tests. But, as I said before, this is a book of fundamentals, and I think there are a few much more basic things than matters of personnel administration for which I would rather use the limited space I have available.

Labor Is Not a Commodity

Although they would be the last to admit it, many of our older industrialists cannot abandon the idea that labor is a commodity to be bought and sold at the market price. Even the unions haven't thrown off the idea entirely as evidenced by their continual references to the "prevailing rates in the district." What is the prevailing rate but the market price?

When labor is bought and sold at the market and men are hired and fired at will, there is a quality of slavery about the whole thing. Not slavery of the old kind in which the man was owned body and soul by the master, but a different sort that is none the less complete. Some of our more "progressive" economists call it "economic slavery." Although I don't like the term any more than I like the source, and I am not an admirer of the "new economy," you have to admit it is somewhat apropos.

The employer says to employee, "I am going to pay you 69½ cents per hour because that's all I can afford, and if it is not enough, you can go elsewhere," apparently leaving the man a free choice, but where elsewhere? In the large manufacturing centers the man usually has a choice, but in the one-plant town, where can he go? He owns his home, his family are rooted there, and it is not a simple thing for him to pack up and go. His cost of moving would absorb any reasonable differential in wages for a long time, and in ordinary times he would suffer a capital loss on his home through what would undoubtedly be a forced sale. If he were to go without his family and leave them to dispose of the house in a leisurely way so as to protect his investment, the added cost in living expenses would probably more than offset the differential. He is an "economic" slave, for he must accept the employer's offer on economic grounds alone. This illustrates only one of many ways in which the workman's lot is not a happy one, and all together they have led to the taking of collective measures for protection. In complaining to me of some injustice of the management, a laborer in Pennsylvania said, "Mister, that's why unions were born." Think that one over!

The American workman does not like to be treated as a commodity, and his principal reason for objection is that he is an *American*. He likes to feel that he is an important part of his company—a valuable member of the team—and the enlightened employer wants him to feel so.

The Worker's Interest in the Enterprise

Some time ago one of the unions came out with a statement to the effect that, in their opinion, the workers had a "proprietary" interest in the business. Everyone was amazed, myself included, to think that unionism had finally gone that far. I was so concerned that I made it my business to talk with a lot of union men and union officials about it. I discovered a peculiar thing. Almost everyone I talked to said that they honestly believed they had such an interest. I then asked them if the business were liquidated or sold would they expect to be given any part of the proceeds? They all said, "Oh, no! It's not that kind of an interest. That's a financial interest," or words to that effect. What they meant was that they had worked there for a long time, and the growth of the business was in some measure due to them. They performed their jobs to the best of their ability. Since they hadn't been fired, their efforts must have been at least satisfactory. Since they were a living part of the organism that went under the name of the business, they wanted to be and, in fact, were entitled to be treated as vital parts of it, as much so, at least, as the lathes, the planers, and other inanimate machines. They, the ones I talked with, felt not so much that they had an interest in the business as that the business was obligated to have an interest in them.

The Good Old Days

Many of the manufacturing executives are more or less patiently awaiting the return of the good old days. They are going to be bitterly disappointed because the good old days are not coming back, whether we like it or not. The rules have been changed, and we are going to have to take it and like it, adjusting ourselves as best we can. At present there are many injustices to the employer, perhaps just as many as used to exist for the worker; but, at the risk of being called a "starry-eyed optimist," I am going to predict that these will gradually be ironed out, and once we have made the adjustment to the new rules we will not be as badly off as we may think.

A consulting engineer, being more or less of an educated tramp, gets around a lot. He rides the cushions, as the saying goes, rather than the rods, and nowadays a lot of young people are doing the same thing. I talk to them whenever I can, and they display a marked unanimity of opinion. They look at the situation pretty much alike and are generally of the opinion that the trouble is largely due to greedy and unintelligent leadership in the unions. When the time is ripe, instead of being antilabor, these boys will join the unions and toss the racketeers out. When this happens, and I want to caution you that it won't happen overnight, we will have to deal with honest unions and conscientious leaders, and many of our troubles of today will disappear.

Honesty

Now a word about how we employers must behave ourselves in order that we will not be responsible for making more trouble. There is one keyword that we must keep always in mind. It is *honesty*. We must be honest with ourselves and honest with our associates. Shakespeare said, "To thine own self be true, and it must follow, as the night the day, thou canst not then be false to any man." We must realize that the workmen in our plants are human beings and that they react to various stimuli in the same way that we do. We must not let their position on the economic ladder interfere with their rights as human beings. Rather we should bend the other way and do for them some of the things that they cannot do for themselves. Yet we must be careful to avoid paternalism. The workman wants nothing given to him as a pure bounty, and he must be made to feel that he earns that which he receives. When a company installs a pension plan or makes a group insurance contract, they should be careful not to give the men the idea that they are receiving a bountiful gift. They are not, and it is dishonest to try to make them believe it. It is much better to say something like this. "The company asks its employees to give unstintingly of themselves to further the company's interest. In return it is only fair that the company take such measures as it can to protect the interests of the workmen." After all, that is what it really amounts to, isn't it?

If the company really and honestly has the interest of the men at heart and does for them those things which the individual cannot do for himself, the men will reciprocate by exerting themselves in the company's interest.

Annual Incomes

Mr. Nunn of the Nunn-Bush Company is said to have remarked, "It is my belief that the disposition of the working men to react favorably to a fair proposition is much more pronounced than when dealing with the average businessman. I have had many unfortunate experiences dealing with businessmen who, with lawyers at their elbows, seemed disposed to acquire not what was fair but what they could get." Mr. Nunn has been notably successful in dealing with his workmen. He has instituted a plan by which nearly all his men have a guaranteed yearly income, and it will be found that this is one of the most sought-after conditions by all unions, and it is not without advantages to the management. If you look into manufacturing organizations anywhere, you will find that the executive and supervisory personnel are almost always loyal to the company. Their relative security and yearly salaries make them feel that they are a part of it; whereas, the workingmen, being the first to go when the business slacks off, do not have this feeling.

It would do a great deal to boost morale if employers would devise some way of putting the workmen on an annual income basis instead of the usual hourly rate. The hourly wage plan tends to divide the men and the management into opposing groups that are antagonistic to each other, but if the management applies real brains and effort to the problem considerable progress can be made.

Recognition

Another thing to remember is that all men crave recognition. They like to feel that those in command know of their existence and appreciate their efforts. To give them this feeling costs nothing and increases the morale enormously.

One very successful executive whom I know has his personnel department keep him informed of all vital statistics in his plant. Every day a list of birthdays, marriage anniversaries, and other important events is placed on his desk. He sends messages of congratulations over his signature to those concerned, and on his daily trip through the plant stops to congratulate new fathers and to inquire how Bill's wife is doing after her operation. They love it, and they think he is the salt of the earth.

Then, too, never forget to praise people. Even if they don't deserve it, do it anyway. They know whether they deserve it or not, and, if they don't, they will try harder, for they won't want to miss it.

IN YOUR RELATIONS WITH LABOR

DO	DON'T
1. Consider the workman as a human being	1. *Don't* consider labor to be a commodity
2. Recognize him	2. *Don't* be paternal
3. Praise him	3. *Don't* long for the good old days

CHAPTER XIII

PLANNING PRODUCTION

Even a poor plan
is better than none.

PLANNING PRODUCTION

THE need for planning production has been brought about by the increasing demands that have been made on all kinds and types of manufacturing facilities. The interrelation of modern plants where one depends on the other makes it impossible for us to rely any longer on haphazard methods. A delay in a Cleveland plant, producing parts, may tie up three plants in Detroit and two in Chicago.

There are two principal types of production planning. The first is long-range planning and covers periods of from a year to a cycle of many years and the other is the more immediate type that schedules production from day to day within the plant. The purpose of long-range planning is to eliminate seasonal or cyclic peaks and to keep production at fairly constant levels throughout the period. We will not concern ourselves, herein, with cyclic planning but limit our scope to the yearly kind and endeavor to eliminate seasonal fluctuations.

Inventory Regulation

There are three usual methods of doing this, each of which regulates something, or tries to, and all of them depend upon some system of forecasting. The most commonly adopted method is to regulate production to accumulate inventories and then "even off" by expansion and contraction of the inventory. Once an inventory has been accumulated the production rate may be set and held constant throughout the year at the value determined by dividing the output or sales forecast by the number of working days in the year. In the busy season the inventory would shrink to carry the peak load, and in the off season it would expand again to normal. At the end of the year any error in the forecast would be reflected in the size of the inventory.

Distribution Regulation

Another method of reducing the seasonal variations is to attempt to influence the distribution. This can be done by reducing prices or increasing advertising in slack seasons to augment the demand or by encouraging jobbers or dealers to carry the cushion inventory. This may be done by making more attractive prices for delivery in off seasons. A variation of the distribution regulation method is to develop new products that can be produced largely on the same facilities, but whose seasonal peaks are not in phase with the existing products.

Personnel Regulation

The third method of stabilization is convenient when departmental loads are normally out of phase with each other. This consists of transferring employees from one product group to another. It is called personnel regulation. Many companies are asking their employees to take their vacations in off-peak periods. This is a variation of the personnel regulation method and can be of some but not great help.

Outstanding examples of long-range planning are the telephone and utility companies. It is vital to them to plan for expansion for many years ahead because underground installations and other items of plant expansion are so expensive and take so long to install that to do otherwise would result in continual chaos.

In any system of planning in which production schedules are set, it is equally important to set quotas or schedules for sales and these should be as rigidly followed up and controlled as the production schedules.

Scheduling

The second type of production planning is generally referred to as scheduling and should be closely integrated with such control measures as are adopted. The long-range planning is generally done by the Executive Committee, and the plans are usually ratified by the Board of Directors, but the scheduling is generally a part of the Production Control Function.

Production planning and control within the plant always stem from some form of master schedule, often called the "master delivery schedule," which lists the quantities of each product promised for delivery with the promised dates of shipment. The first step should be to examine this schedule for, let us say, the month of October, and endeavor to group similar orders to get the longest production runs possible. We are, of course, planning well in advance. Let us assume that we are in the month of August and that the Process Engineer has supplied us with all available data on how products are to be made. This is very essential. We will further assume that we have to deliver 2,000 units of product C-31 on or before Oct. 25.

Upon consulting the process data we find that C-31 is an assembled unit containing several parts, and we find the standard assembly time to be 6 min. each and that we have available 10 stations. That means that we can assemble the units at a rate of $6/10$ min. each or 100 assemblies per hour. It will then require 20 hr. to assemble the 2,000 pieces so we had better allow 3 days of 8 hr. each to provide a little come and go. We then extend our delivery schedule backward and say that parts for 2,000 units shall arrive at assembly on Oct. 22.

Upon examining the part lists, we find that each unit required 2 ball bearings that are a "purchased finished" part, and our stores record shows 4,500 of them unallocated in stock. We are OK on this item. We allocate 4,000 ball bearings to this order, and the stores clerk prepares a requisition for additional bearings to replace the stock in accordance with his detailed instructions. We schedule the 4,000 bearings for delivery to the assembly stations on Oct. 22 at 8 A.M. or possibly on the afternoon of Oct. 21.

The next item on the parts list is the housing castings. These take 20 min. each to machine on the turret lathes, and we will have 4 lathes available. The rate on this operation is 5 min. per housing or 12 per hour. That means it will take 2,000 divided by 12 or 167 hr. to do this operation so we must schedule it to begin about 21 working days before Oct. 22. This brings the starting day for the housings back to Sept. 18. To procure these castings from the foundry, the purchasing agent tells us it will take about 2 weeks so the order must be placed by Sept. 4.

Each part must be considered separately, and the starting time must be determined for all in either the manner outlined or similarly, and the result is the expansion backward of the master schedule. Accurate records must be kept of the allocation of parts or materials in stores as well as the allocation of the machine times used in extending the master schedule. This latter record is usually called "load control," and by keeping it well in advance, it is possible to know how much, if any, work must be subcontracted for on the outside or how much overtime will be required in order to meet the master schedule.

Material Control

Having prepared, and extended backward, the master schedule, let us now consider the methods for controlling the production. All items of material should be followed up by the Material Control Manager, who will issue the necessary purchase requisitions to the Procurement Function and who will expedite deliveries. He will also be in control of all storerooms and will be responsible for the flow of materials everywhere in the plant.

Dispatching

Next comes the function of dispatching. This consists of the preparation of shop orders in accordance with the master schedule and their issuance to the shop at the proper times. These orders should then be followed up according to some regular plan to make sure that none is sidetracked or forgotten. A regular system of reporting on progress of orders against schedules should be inaugurated and maintained. These reports should go to the Production Manager who can then act on any delinquency or perhaps act on a probable delinquency before it becomes a fact. In this way a great deal of trouble can be avoided and what cannot be avoided can be minimized.

Procedures

The procedures for planning and control of production vary considerably with the type of plant and the industry involved and should rightly do so. It can be readily appreciated that the same procedures would not be applicable to controlling the production of hydraulic turbines, which take a matter of years to design and build, and to machine screws for which the production rate may be measured in thousands per hour. However, there are many efficiency experts today who try to sell packaged systems to any and all manufacturers. Although the principles involved are markedly similar, the best system of procedures can be arrived at only through a study of the particular application and it must, even then, be developed by trial and error.

Installation

The installation of planning and control procedures not only requires some study but a large amount of tact. Many executives, thinking to save time and fuss, will try to install a system of procedures by fiat. This never works for the simple reason that those whose responsibility it is to operate the system will do so, if at all, in a dilatory manner and try to blame any shortcomings on the system itself. It is far better to form a committee or group to whom everything is completely explained and who are "sold" on the possibility of successful operation. The committee should then attempt to ease the system in gradually with the least possible displacement and disruption of the *status quo.*

IN PLANNING YOUR PRODUCTION	
DO	DON'T
1. Determine the best method 2. Adopt a plan 3. Follow through	1. *Don't* depend on chance 2. *Don't* buy packaged systems 3. *Don't* install a system by fiat

CHAPTER XIV

MANAGEMENT CONTROLS

Hirohito had no control.

MANAGEMENT CONTROLS

THE chief executive of a company is responsible to the Board of Directors and through them to the stockholders for control over the application and profitable use of the resources placed at his disposal. He, in turn, must delegate the responsibility for the various phases of this problem to groups of functional specialists in the fields of engineering, marketing, etc. The extent to which he finds it necessary to delegate this responsibility is largely dependent upon the size and complexity of the business as well as his capacity for undertaking the work himself. The tendency of most executives is to overestimate their own capacity and load themselves down with a terrific amount of detail that interferes with objective consideration of the most important problems. Many executives, feeling that the abilities of their subordinates are not equal to their own, are reluctant to pass on their responsibilities for fear of not getting as good a job done as they could do themselves. The net result is usually that they get no job done at all, and I submit that it is far better to have something done, however less comprehensive, than to have the responsibility entirely neglected. Perhaps the underlying reason for the reluctance of many executives to delegate responsibilities to others is that they do not know how to establish controls and they fear that once the responsibilities are out of their hands they can no longer control them.

When responsibilities are delegated in this manner and authority coextensive therewith is granted, it becomes necessary to provide a series of accounting and statistical reports which will make it possible for the executive to be continuously aware of the degree to which his subordinates are effectively using their authority and discharging their responsibilities. The setting up of these accounting and statistical procedures constitutes the establishment of control, and it is the control so established that constitutes the difference between delegating responsibility and passing the buck, a practice we have all engaged in at various times.

Functions

Figure 21 consists of a chart prepared by Mr. Kenneth G. Neal showing the relation of the various functions of control to Administration and Operations. On the right-hand side of the chart Administration and Operations are shown connected by two "tubes" representing the delegation and discharge of responsibility. In the lower-left-hand corner is shown the Accounting function also connected with Operations by two tubes. The lower tube represents the flow of the paper work such as material movement records, time tickets, etc., and the upper tube represents the reports prepared from these data flowing back to Operations to assist them in the supervision of the work. A vertical tube extends upwards from Accounting to the Comptroller and represents the flow of tabulations prepared by Accounting from the paper flow represented in the lower horizontal tube. The Comptroller is, in turn, connected with both Administration and Operations by a horizontal tube and a diagonal tube. The Comptroller summarizes, interprets, and analyzes the tabulations received from Accounting, sending the summaries and interpretations to

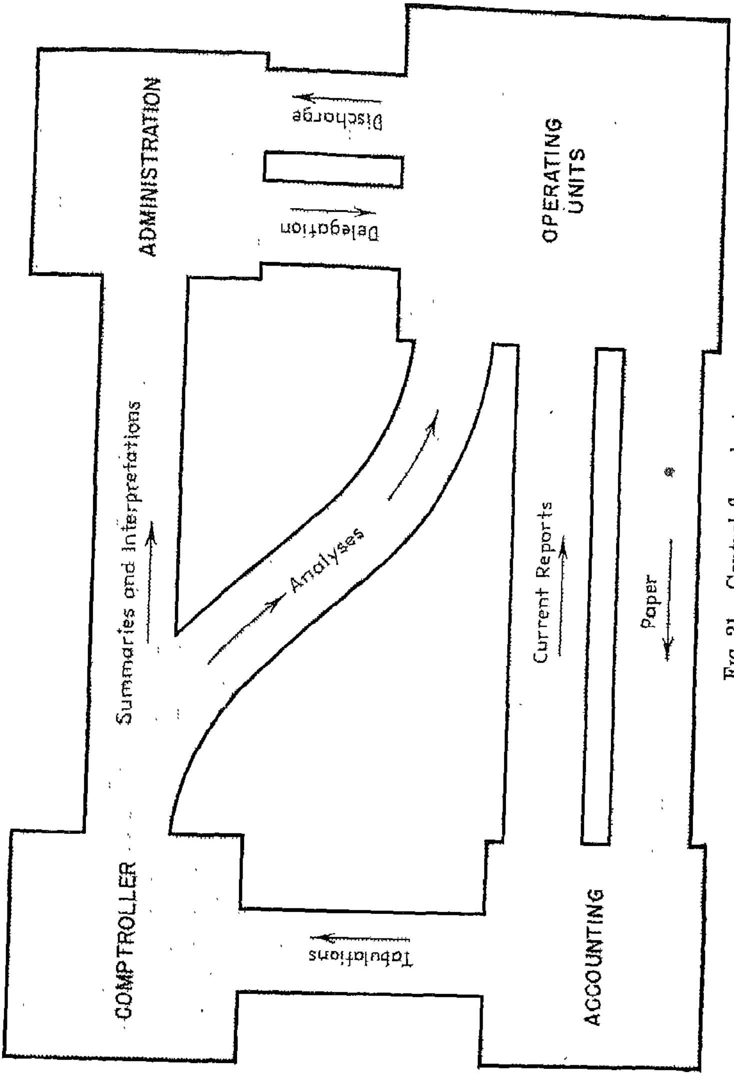

FIG. 21.—Control flow sheet.

Administration and the analyses to Operations that they may apply any corrective measures that are called for without pressure from Administration. Should they fail to correct, Administration may then apply such pressure or take such action as the case warrants. Perhaps to oversimplify one may define Controls as a system of procedures that keeps everyone continuously informed of what is going on.

In considering further the subject of management controls, there are three questions that come to mind:

1. Why control?
2. Control what?
3. How is it done?

Let us take these questions one at a time. Of course, the ultimate reason for control is to provide consistent, long-term net profits for the enterprise, and in order to accomplish this, the chief executive must keep in constant touch with all the activities of the enterprise. The closer he keeps in touch with the various important items the sooner he will be able to apply remedial measures if anything starts to go wrong, and much time and expense can be saved through an early remedy or the anticipation of a defection.

The second question, asking "Control what?" can be answered as follows: There are three principal things that have to be controlled very carefully.

First is the direction of effort of the personnel. All the people who make up the company's organization should be consistently working toward the same end or goal. They should work as a team, each doing the specific tasks assigned to him, cooperating and coordinating his efforts with those of others.

Second is the property of the enterprise and includes all the items of property such as land, buildings, facilities, finances, and good will. All these things must be kept constantly in hand to avoid their dissipation or loss. Unnecessary capital items should be converted into money as advantageously as possible and at such a time as may avoid excessive depreciation or obsolescence.

Third is costs. Although last upon the list, this item is by no means the least important, and unless the operating costs are definitely and continuously controlled, the enterprise can swing from the profit to the loss columns quicker than you can say "Jack Robinson." It is impossible to say too much in favor of good cost control, which, of course, depends for its operation on a good cost accounting system.

Case XXXI—*The Case of the Vanishing Profit*

As a horrible example of lack of cost control, I want to tell you of a large plant that makes a huge variety of shapes and sizes of related products. Previous to 1944 this plant had no way of determining unit costs, and, although they knew that some of their products showed a considerable loss and others an enormous profit, they could not tell which except for the very extreme cases. The products were sold on a weight basis and varied from 1 to 100 lb. each. The amount of labor involved in making the 100-lb. product was only about 3½ times that involved in making the 1-lb. product, yet the price ratio was 100 to 1. There was no question whatever but what the profit on the 100-lb. article was unconscionable, and the loss on the 1-lb. product was terrific, but where the break-even point was no one knew. They excused themselves on the basis that they had to carry a complete line and that it averaged up over a period of time. When I was consulted about these matters, the first question that occurred to me was "Does it average up?" After a careful check I found that it did not. The break-even point came somewhat higher than the "center of gravity," which meant that the more they sold the more they lost, and yet they were

> not even in a position to tell the sales department to push certain items and discourage others. They were not really making money through manufacturing; they were simply gambling on how the orders would fall, and when a true picture of their unit costs was finally obtained, it called for a complete change in the basic policies of the company to save them from eventual ruin. How much money they lost in the meantime, God alone can tell. Their profit or loss was obtained monthly by subtracting what they spent and what they took in, and in the particular division in question it was nearly always in the red. Other divisions of this plant were in similarly bad condition through the same cause, but due to a fortuitous freezing of price structure at an advantageous point, they managed to keep a hop, skip, and a jump ahead of the sheriff.
>
> The establishment of an adequate system of cost control is now helping them out of their difficulties. So far, they at least know what items they are making on and what items they are losing on. It will probably be impossible to eliminate all the loss items since in their particular industry you have to take the "bitter with the better," and in order to keep their large customers they have to supply them with certain items at a loss. However, most of the loss items can be eliminated or minimized, and the sales department can be told where to bear down. The net result, of course, is obvious.

The answer to the third question "How is it done?" may be divided into three parts also. *First,* get the facts. This is done through the medium of accounting and statistical reports that must be properly arranged and presented to show the information in consistent and readable form. The *second* is to interpret the facts. This is done by evaluating the information obtained and comparing it with standards of some sort or other. The standards may be arrived at through analysis of previous performance or they may be arbitrarily set by consideration of the desired performance. Whatever means are used to establish the standards, they should not be considered as permanent but should be altered from time to time as seems justified. *Third,* act accordingly. This means "Go to town." When performance is not up to standard, remedial measures should be taken forthwith. Delay at this point is deadly and should be avoided. The good executive, upon interpretation of the facts, will make a decision rapidly, and the decision must be followed with prompt action. To delay costs money for every minute, and no more time should be lost than is absolutely necessary in order to make the remedial measures effective.

IN CONTROLLING YOUR ENTERPRISE	
DO	DON'T
1. Delegate responsibility 2. Grant the necessary authority 3. Carefully consider the reports you receive 4. Make decisions and act promptly	1. *Don't* pass the buck 2. *Don't* try to do it all yourself 3. *Don't* interfere with your subordinates 4. *Don't* fail to help your subordinates when they need assistance

CHAPTER XV

RESEARCH AND DEVELOPMENT

Seek and ye shall find.

RESEARCH AND DEVELOPMENT

ALTHOUGH not usually an organic part of manufacturing, research has become one of its most valuable adjuncts in recent years. For this reason I should like to discuss some of its aspects in relation to the manufacturing enterprise before closing. The word itself, not unlike "production," has come to have several meanings and this unfortunate state of affairs has, no doubt, been brought about or at least augmented by its Latin derivation. I am not much of a Latin scholar, but I have been told that the word from which it derives means, literally, "to go around again in circles." At first glance this does not seem very complimentary to researchers in general, but if you think about it for a moment or two you will appreciate how apropos it really is. Whenever you try to find something, you "search" for it, which means, literally, to go over and over the places where you think it may be until you either find it or give up the job. This is just about what researchers do, only they are not looking for a lost object but for one whose existence they may only suspect, and it is seldom that they find it either the first time around or where they think it may be. Sometimes they find something else that is even more important than the object they are searching for. Then, too, the object of the hunt is often very elusive. It may be a natural law, just a fragment of truth, or even a bit of corroborative or contradictory evidence relating to some abstruse hypothesis.

There are three kinds of research that are important to the manufacturer, and all of them are loosely called by the same name. Let us take them up one at a time and more or less define them. All are a form of scientific inquiry.

Market Research

The first is market research and is the kind that inquires into the marketability of a product. This can be of inestimable value to a manufacturer in determining his program. It can tell him, first, whether or not there is a market for a product; second, how large it is; third, its location; fourth, whether or not some changes in the product would be desirable; and fifth, whether or not the product is correctly priced. Of course, there are lots of other things that can be determined by a thorough market research, but these five are generally considered to be the most important.

There are numerous ways of conducting such a market research, but all of them boil down to asking questions of a representative sample of the potential consumers or users of the product. These questions are either asked by salesmen or other representatives in person or they are propounded in the form of a questionnaire that is mailed or otherwise brought before the selected list of prospective customers. Sometimes the questions are asked over the telephone and sometimes more subtle means are used to get the information.

It is difficult to overestimate the value of such a research or "market survey" as the following example will show.

Case XXXII—*The Case of the Doctors' Dilemma*

One of my clients, a manufacturer of electronic devices, had expended a great deal of effort in redesigning a very heavy, cumbersome, and expensive medical instrument. Previously these devices, in crude form, were only to be found in hospitals and the offices of Park Avenue and Harley Street physicians. Through his knowledge of electronics he succeeded in producing an instrument that would do all the big machines could do and a great deal more. He reduced the size of the gadget to about the same as that of the doctors' familiar black bag and its weight from four hundred odd pounds to 26 lb. The price came down almost in proportion to the weight, and the idea was to offer the doctor an instrument that he could conveniently carry on his professional calls as well as in his capital accounts.

The next step was to investigate its acceptability to the medical profession as a whole. A list of physicians was obtained who might possibly be classed as prospective customers, and representatives were sent to call on them with laboratory models of the improved instrument. The manufacturer very wisely took this step before tooling up for production.

The physicians called on were almost unanimous in their reaction. The consensus of opinion was that although the instrument was ingeniously contrived and amazingly efficient, they could scarcely charge a patient much of a fee for using so small and innocent-looking a machine on his person regardless of the therapeutic effect. One striped-trousered disciple of Hippocrates offered to give the researcher, then and there, an order for a machine at five times the price if he would add some switches, meters, and flashing lights and mount the machine in a mahogany console measuring about 4 ft. wide, 6 ft. high, and 2 ft. deep.

The manufacturer, being a man of very delicate sensibilities, upon completion of the survey, decided not to enter the field of medical instruments.

Fundamental Research

The second kind of research of interest to the manufacturer is fundamental research and is that which inquires into the fundamental laws of nature. The investigations that led to the invention of the atomic bomb are examples of this kind of research. Before the atomic bomb could come into being there was an enormous amount of inquiry that had to be made into the structure of the atoms themselves. Before anyone could reasonably expect to cause atomic fission, the term used to describe the spontaneous breaking up of an atom, it was necessary to determine as exactly as possible how the atom was put and held together. These researches were commenced many years before the atomic bomb became an actuality, and since there were known to be 92 different kinds of atoms, all of which had to be investigated for one reason or another, this was a man-size job from any angle.

Fundamental research is inclined to be on the expensive side and is definitely a long-range proposition. However, it is usually quite profitable. Many of the larger companies, such as the General Electric Company, Westinghouse Electric and Manufacturing Company, General Motors Corporation, etc., spend huge sums each year, and have for many years, on fundamental research. That such expenditures pay in the long run is shown in the following example:

Case XXXIII—*The Case of the Dollar's Return*

> While I was writing this chapter a friend dropped in who used to work for General Motors. We were discussing research in its various phases, and he told me that General Motors' royalties from the Ethyl gasoline patents more than pay the entire expenses of their enormous research laboratories.

Another example of the value of research to our great industrial organizations is the following:

Case XXXIV—The Case of the Undersized Ducts

For many years the Consolidated Edison Company of New York has maintained a small but remarkably well-equipped research laboratory. There came a time, not long ago, when the load in the Borough of Brooklyn became so great that an increase in the carrying capacity, and hence the size, of the underground cables throughout the area of the downtown section became necessary. Most of the cable ducts were full and the size of the ducts were such that no larger cables could be pulled through them. This meant the tearing up of all the streets and the installation of new and larger ducts to accommodate the larger cables. The research laboratory went to work on the problem, and under the direction of Mr. Ward F. Davidson succeeded in perfecting a new method of insulation that allowed the use of 27,000-volt pressures instead of 13,000 volts, then in use, without increasing the cable size. This doubled the power that could be carried through the existing ducts and saved tremendous delay and expense. If nothing else came out of the laboratory for 10 years or so it would still have been in black ink after that job.

Research in Universities

Recently a new movement has gained considerable momentum with manufacturers and small organizations who cannot afford the expense of extensive research facilities. A number of them will band together, contributing according to their abilities, to finance fundamental research projects in colleges and universities. The projects are, of course, those from which it seems probable that useful data will be obtained for individual contributing concerns. A short time ago a prominent furnace manufacturer, who has a medium-sized business, told me that he had clubbed together with a number of his competitors to finance a fundamental research project in combustion. He said that he felt the data they expected to obtain would be very valuable to all of them, and the cost when divided would not be great. Which one received the most benefit would, of course, depend on the use to which the data were put.

The apparatus necessary for many fundamental research projects is very expensive, particularly in nuclear physics since no one gives cyclotrons away with a pound of tea, and only the largest concerns can afford it. Many universities maintain such apparatus and employ it at a much greater use factor than could any individual company. The labor costs to a university are also much less since a great deal of the spade work is done by graduate students who are anxious to get the experience.

Another point in favor of manufacturers calling upon universities for their fundamental research is that it supplies practical projects for the training of our future scientific personnel. It not only adds to the general store of knowledge but to the specific store of each student working on the various projects, and it raises the general level of scientific attainment throughout the nation. It is needless to point out that the scientific superiority of the Western Allies and particularly of the United States was a great factor in the swift and decisive winning of the Second World War.

Applied Research

The last of the three kinds of research of interest to manufacturers is applied research or, as it is sometimes called, "development." Considering applied research in contradistinction to fundamental research, one may call the latter "analytic research" and the former "synthetic research," since one takes the problem apart and the other puts it back together again. Fundamental or analytic research breaks the problem down into its various elements, determining the natural laws that apply and their application; whereas, applied or synthetic research reassembles these elements endeavoring to arrange them in new and useful combinations. The two are entirely complementary to each other, and it is often very difficult to determine the exact point where one leaves off and the other begins. One might be inclined to think that without fundamental research applied research would be valueless, and theoretically he would be right. From a practical viewpoint, however, we must recognize that throughout the years fundamental research has amassed an enormous volume of data, and this alone would be sufficient to keep all the applied research laboratories of the world going for a long time. Another name for the science of engineering is "applied physics," and it will be readily appreciated that even if all the physics laboratories in the world were to shut up shop it would be some time before engineering would have to toss in the sponge.

Applied research is a field that any manufacturer can enter to almost any extent he desires. The necessary tools vary between rather extreme limits. On the one hand there are the very expensive and extensive development laboratories of the large companies, and on the other, a simple workbench and a few hand tools have been all that was necessary for some rather startling developments. The following case will serve to illustrate in a way how much can be done with very little:

Case XXXV—*The Case of the Ancient Inventor*

One of the most extreme cases I have ever known was that of a client of my father. He was a very old gentleman whom we shall call Mr. *A*, and I believe him to have been one of the greatest sheet-metal workers of the times.

Mr. *A* lived in a two-room apartment in one of New York's fashionable hotels, and his only tools were a sharp knife and a bottle of glue. His materials consisted almost entirely of the cardboards that came from the laundry in his shirts. He used to sit for days on

> end at a card table in the living room cutting out models of his various inventions and gluing them together. In this way he produced a prodigious number of great developments in the sheet-metal field, and he was one of the pioneers in the field of electric-resistance welding. He maintained that spot welding more nearly approached his bottle of glue then anything else.
>
> Mr. *A* was a most amazing character, and at the age of eighty-nine he came to my office to ask my advice as to whether or not he should accept an offer from one of the great manufacturers of Pittsburgh. They, it seems, had offered him a job at a salary of $25,000 per year. I was flabbergasted and asked what was holding him back. He said he felt it was a temporary thing and had no future in it.
>
> I could not think of any words to express what was in my mind and yet I didn't want to laugh at the old gentleman so I said that I felt that he alone could make such an important decision. After a few further remarks he said he had decided to turn it down and left. The funny part was that his decision turned out to be right for he lived to be well over a hundred years old and did some of his best work after that. He worked at his card table right up to the last, and his mind remained active and strong.

I heartily recommend that every manufacturer engage to the limit of his ability in applied research and also that they organize the activity and support it both morally and financially. Many companies have little independent "cells" located here and there about their premises where Handy Andy and his various counterparts work sporadically on developments of one kind or another. They usually have managed to get hold of an old dilapidated drill press and a few meagre hand tools and are continually working up hill. Andy is usually very reticent about his activities for fear that he will be criticized for wasting the company's time or be called a "crazy inventor." The more "practical" men in the shop are wont to look down their noses at him as something of a visionary (as though that were something to be ashamed of) and twit him about his "Goldberg inventions."

Applied research is usually concerned with three things, and anyone must admit that all of them are of vital and significant importance to any manufacturer. These are

1. The development of new products
2. The improvement of old ones
3. The development of processes

Development people, good ones at any rate, are different from most other personnel. It must be remembered that they are creators and are apt to have more or less artistic temperaments. This is always decried by those not having creative ability, and the reason is evident. All of us, however hardheaded we may be, would like to possess creative abilities whether we know it and will admit it or not, and when life has shown us that we have no such talent, or comparatively little of it, even when our other talents are great there is a tendency for us to belittle it in others. It is undoubtedly a form of jealousy and, although unpleasant to contemplate objectively, it is a fact that we will sometimes go to great lengths to show how much more important are the talents we do possess. Psychologically this is known as overcompensation and should be carefully guarded against.

The organization of a group for applied research or development is a very ticklish thing and has to be very carefully handled to get the best result. It is very important not to overorganize as the people involved are prone to resent deeply even the slightest tinge of regimentation. I believe they are justified in this feeling, since the more complete their freedom of movement and action the clearer their minds will be to create those things which are of great value to the company and which afford this particular kind of person such great personal satisfaction. The following case is rather interesting and illustrative of this point of view.

Case XXXVI—*The Case of the Engineer's Thumb*

> One of our prominent manufacturers had recently effected a complete reorganization of his development laboratories wherein everyone was completely circumscribed. One of the boys who had been a veritable spark plug in the past complained to me one day as follows: "How," he said, "can I suck anything out of my thumb with gloves on?" (In laboratory parlance the getting of an idea from apparently nowhere at all is called "plucking it from the blue," or "sucking it out of your thumb.")

Perhaps the most important thing in the organization of your development activities is the choice of the director. There is a tendency on the part of many companies to choose a man of ponderous intellect to lead the group. This is usually wrong, although the ponderous intellect of itself is not so much of a drawback, but those so gifted are generally of the introvert type and are not good leaders, especially of research people. It is something like selecting the best workman to be the foreman. You often lose a good workman and get a poor foreman.

The first rule, in my opinion, is that the director should definitely be an extrovert. Research is always under attack by those in other activities, largely for the reasons stated above, and it requires constant "selling" of the group and its work to the others in the company. The extrovert is also much more prone to attack vigorously the seemingly impossible than is the introvert. Say, if you will, that "Fools rush in where angels fear to tread," but it is axiomatic that you will not *come out* with anything unless you *go in* after it. Case XXXVII illustrates the mistake of selecting an introvert as the director of research activities.

Case XXXVII—*The Case of the Ponderous Brain*

Some years ago a large company established a laboratory for both fundamental and applied research. They selected as its director a man of profound intellect and profluent knowledge. He was a charming and delightful luncheon companion in spite of the fact that he was addicted to carrying his cane even in the subway. He could converse learnedly on practically any subject, and, although my acquaintance with him covered a period of many years, I never found any branch of human endeavor about which he was uninformed. He would remind you of no one as much as the famous character of the campus ballad, Ivan Skavinski Skavar, who could imitate Irving, play poker and pool, and tickle the Spanish guitar . . . although his accomplishments were more in the field of color photography, symphonic music, and the mysticism of the East. Alas, and sad to state, however, our hero was a perfect introvert and in no sense a leader.

His laboratories performed many valuable researches and were a great asset to his company, but this man simply could not "sell" himself, his people, or his work. In spite of the fact that he was really a very modest fellow, he succeeded in creating a "holier than thou" impression on nearly all the people in the company outside of his own little group who really knew the man and admired his great mind. As was to be expected, the personality of the director filtered down through the entire laboratory personnel and almost without exception they came to be cordially disliked by the rest of the organization.

Perhaps the largest single factor contributing to this unfortunate situation was that he loved to say, "It can't be done." When an executive of another department went to him with a problem such as a request for the development of an instrument to measure this or that, his eyes would light up and he would reply something like this, "Well, Fred, I am glad you came to me with this for I happen to know that it cannot be done for the following reasons." Then he would enumerate never less than a half a dozen very plausible reasons why it was impossible to develop the particular thing in question.

The executive making the request was often not content to accept the verdict because the reasons given were so far over his head that he could not understand them and was loath to admit his ignorance. He would then surreptitiously slip the problem to one of his Handy Andys who would, more often than not, come up with the answer.

The projects originating in the laboratory, however, fared differently. Although I am entirely convinced that there was no intentional dishonesty on the part of the director, the difficulty of convincing the rest of the organization of this can readily be appreciated.

It was only to be expected that the unpopularity of the researchers with executives and others in the company would eventually reach the Board of Directors, which, of course, it did and soon the entire organization was "out to get 'em."

The work of the laboratory on the projects initiated therein was of such a high caliber and of such great value to the company that the Board withheld any unfavorable action but took on the nature of a compressed spring. The war provided the trigger action necessary.

Another company that was more deeply engaged in war work offered to buy the laboratory, lock, stock, and barrel, exclusive of the personnel. The Board decided that it was their patriotic duty to sell and did so for a small percentage of its real value. Although they have undoubtedly regretted this action since, the fact remains that it was irrevocably taken and nearly the whole responsibility for it may be laid at the feet of the unfortunate director.

APROPOS OF YOUR RESEARCH ACTIVITIES	
DO	DON'T
1. Engage in as much research as you can afford 2. Support your research activities morally as well as financially 3. Make market surveys as early as possible	1. *Don't* overorganize 2. *Don't* disparage creative talents 3. *Don't* employ introverts as leaders

CHAPTER XVI

CONCLUSION

And so to bed.

CONCLUSION

I WANT to thank the reader, at this point, for having stayed with me so far. I have tried to be as brief as possible throughout but at times, I fear, I have been a little long-winded. I shall try to make up for it, however, by making this chapter extremely brief.

We have covered a lot of territory in this little book, so much in fact, that a great deal of it has been rather sketchily treated. I have made no effort to go into great detail but rather have tried to enumerate the various problems that confront the manufacturer whether he be new at the game or an old hand. I hope the old hands will take my effort in the spirit in which it was made and not be too critical. The book may be of use to them as a refresher course in the fundamentals and, having read it, I hope they will be inspired to take stock at least of their operations and *do* some of those things they have been planning to do for such a long time.

At the risk of criticism for "plugging" my own profession, I want to offer a word of advice concerning Consulting Engineers. As you have seen in reading the foregoing, there are a great many problems that confront the manufacturer. They vary widely but they are all important, and it behooves the old as well as the new manufacturer to obtain the best advice and counsel in coping with them. There are many of us who have spent the greater part of our professional careers in the study of these problems, and we make our modest livings assisting manufacturers in coping with them. It is well to bear in mind that the consultant has worked in many industries and can bring to the client the experiences of many others. Use of the consultant is, in many ways, akin to cross-pollination. He brings ideas from one industry to another and back again very much as the bee carries the pollen from one flower to another. Then, too, in a going concern the busy executive may not be able to take the time from his operating duties to give the special problem the attention it deserves. The consultant is not in this position since the client's special problem is his full-time responsibility. There are many excellent firms of consultants who can be of great service to the manufacturer and their charges are usually quite modest. It is much more economical, as a rule, for the manufacturer to use highly trained consulting specialists than to attempt to carry, on his own staff, men of sufficient gauge and competence to solve the multitude of problems that will confront him from time to time.

Many consultants specialize rather highly. There are those who handle nothing but personnel problems, others who handle problems of control and accounting, and still others who specialize in the technology of manufacturing.

In closing, I want to wish each of my readers the very best of fortune, for if you are a manufacturer you will need it.

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